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Forsmark site investigation

Boremap mapping of telescopic drilled borehole KFM07C

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Abstract

This report presents the results from the Boremap logging of telescopic drilled borehole KFM07C. The borehole was drilled sub-vertically (142°/85°) close to the Forsmark camp area, just south of the nuclear power plant. The main purpose for the location of this borehole was to provide geological and rock mechanical data for the rock volume of the potential repository. The full length of KFM07C is 500.34 metres. The BIPS-image usable for mapping covers the interval 98.46–498.46 metres after length adjustment. All intersected structures and lithologies have been documented in detail by integrating information from the drill core and the BIPS-image. Also the upper and lowermost metres of the drill core, for which no complementary BIPS-image exists (85.21–98.40 and 498.46–500.21 metres), are mapped, but none of the features are oriented.

KFM07C is drilled in the northwestern part of the tectonic lens, which largely corresponds to site investigation area. The predominant rock type in the borehole is a medium-grained metagranite, similar to that in the previously drilled deep boreholes located in the site investigation area. Other frequent rock units within the borehole, none forming occurrences more than a few metres in length, include pegmatitic granites and amphibolites. In addition, there are a few occurrences of fine- to medium-grained metagranitoids, intermediate metavolcanic rocks and one occurrence of medium-grained metagabbro. Virtually all rocks in the borehole have experienced Svecofennian metamorphism under amphibolite facies conditions.

Most rocks in KFM07C are characterized by composite L-S fabrics, with a general predominance of tectonic foliations. Totally four narrow zones of more intense ductile and brittle-ductile deformation have been registered in the borehole. All four are more or less parallel with the local tectonic foliation.

The total number of fractures registered *outside crush zones and sealed networks* during the boremap-logging of KFM07C amounts to 1,924. Of these are 304 open, 49 partly open and 1,571 sealed. In addition, there are 51 sealed networks, seven breccias (or brecciated intervals) and one cataclasite registered in the mapped interval. All breccias are restricted to the length interval 307–379 metres. The total length of all sealed networks in KFM07C amount to 10.7 metres. The most frequent filling minerals within KFM07C are calcite and chlorite. A typical mineral assemblage, commonly found in fractures inferred to be sealed, consists of laumontite together with varying amounts of calcite, chlorite and locally adularia. Except for a few fractures at around 100 metres length, the laumontite-bearing assemblage is restricted to borehole lengths over 270 metres. Various clay minerals are largely restricted to open fractures. Pyrite and sub-microscopic hematite are spread rather equally between open and sealed fractures.

Sammanfattning

Föreliggande rapport redovisar resultaten från boremapkarteringen av teleskopborrhål KFM07C. Borrhålet borrades subvertikalt (142°/85°) i närheten av Forsmarks barrackområde, strax söder om kärnkraftverket. Det huvudsakliga syftet med borrhålets placering var att ge geologiska och bergmekaniska data för bergvolymen i ett potentiellt slutförvar. Den totala längden av KFM07C är 500,34 meter och den BIPS-bild som är användbar för kartering täcker intervallet 98,46–498,46 meter, efter längdjustering. Alla strukturer och litologier i det Boremapkarterade intervallet har dokumenterats i detalj genom att integrera information från borrkärnorna och BIPS-bilderna. Även de övre och understa metrarna, för vilka det saknas kompletterande BIPS-bild (85,21–98,40 och 498,46–500,21 meter), är karterade, men inga objekt har orienterats.

KFM07C har borrats i nordöstra delen av den tektoniska linsen som i grova drag sammanfaller med undersökningsområdet. Den dominerande bergarten i borrhålet är en medelkornig metagranit, av samma typ som den i övriga djupa kärnborrhål i undersökningsområdet. Andra vanligt förekommande bergartsenheter i borrhålet, av vilka inga överskrider ett fåtal meter i borrhålslängd, omfattar pegmatitiska graniter och amfiboliter. Därtill finns ett fåtal förekomster av fin- till medelkorniga metagranitoider, intermediära metavulkaniska bergarter och en förekomst av medelkornig metagabbro. Största delen av berggrunden i området har genomgått Svekofennisk amfibolitfacies-metamorfos.

Flertalet bergarter i KFM07C karaktäriseras av en sammansatt L-S struktur, med en generellt dominerande tektonisk foliation. Totalt fyra mindre zoner med mer intensiv plastisk och spröd-plastisk deformation har registrerats i borrhålet. Alla fyra är mer eller mindre parallella med den lokala tektoniska foliationen.

Det totala antalet sprickor som registrerats och *inte ingår i krosszoner eller läkta spricknätverk* vid boremapkarteringen av KFM07C uppgår till 1 924. Av dessa är 304 öppna, 49 partiellt öppna och 1 571 läkta. Dessutom har 51 läkta spricknätverk, sju breccior (eller breccierade intervall) och en kataklasit registrerats i det karterade intervallet. Alla breccior är begränsade till längdintervallet 307–379 meter. Den totala längden av de läkta spricknätverken uppgår till 10,7 meter. De vanligaste sprickmineralen i KFM07C är kalcit och klorit. En typisk mineralassociation, som vanligtvis uppträder i sprickor som bedömts vara läkta, utgörs av laumontit med varierande mängder kalcit och klorit, samt lokalt adularia. Frånsett några få sprickor runt 100 meters borrhålslängd är de laumontitförande sprickorna begränsade till längder över 270 meter. Olika lermineral är till största delen begränsade till öppna sprickor. Förekomsten av pyrit och submikroskopisk hematit är förhållandevis jämt fördelad mellan läkta och öppna sprickor.

Contents

1 Introduction

Since 2002, SKB investigates two potential sites at Forsmark and Oskarshamn, for a deep repository for spent nuclear fuel 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, sub-vertical boreholes were drilled. 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 provide geological and rock mechanical data for the rock volume of the potential repository. To obtain such information, borehole KFM07C was drilled sub-vertically (142°/85°) close to the Forsmark camp area, just south of the nuclear power plant (Figure 1-1). KFM07C is a telescopic borehole (SKB MD 620.003), in which rock overcoring rock stress measurements were performed (SKB MD 181.001). The borehole has a total length of about 500 metres.

The drilling activities in KFM07C were finished 8 August 2006, and the geological logging of the borehole started 4 September and ended 28 September 2006.

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 KFM07C, 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 400-06-060. 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 KFM07C	AP PF 400-06-060	1.0
Method documents	**Number**	**Version**
Instruktion: Regler för bergarters benämningar vid platsundersökningen i Forsmark	SKB MD 132.005	1.0
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
Metodbeskrivning för kärnborrning	SKB MD 620.003	1.0
Method description for in situ stress measurements by means of overcoring using the Borre probe	SKB MD 181.001	1.0

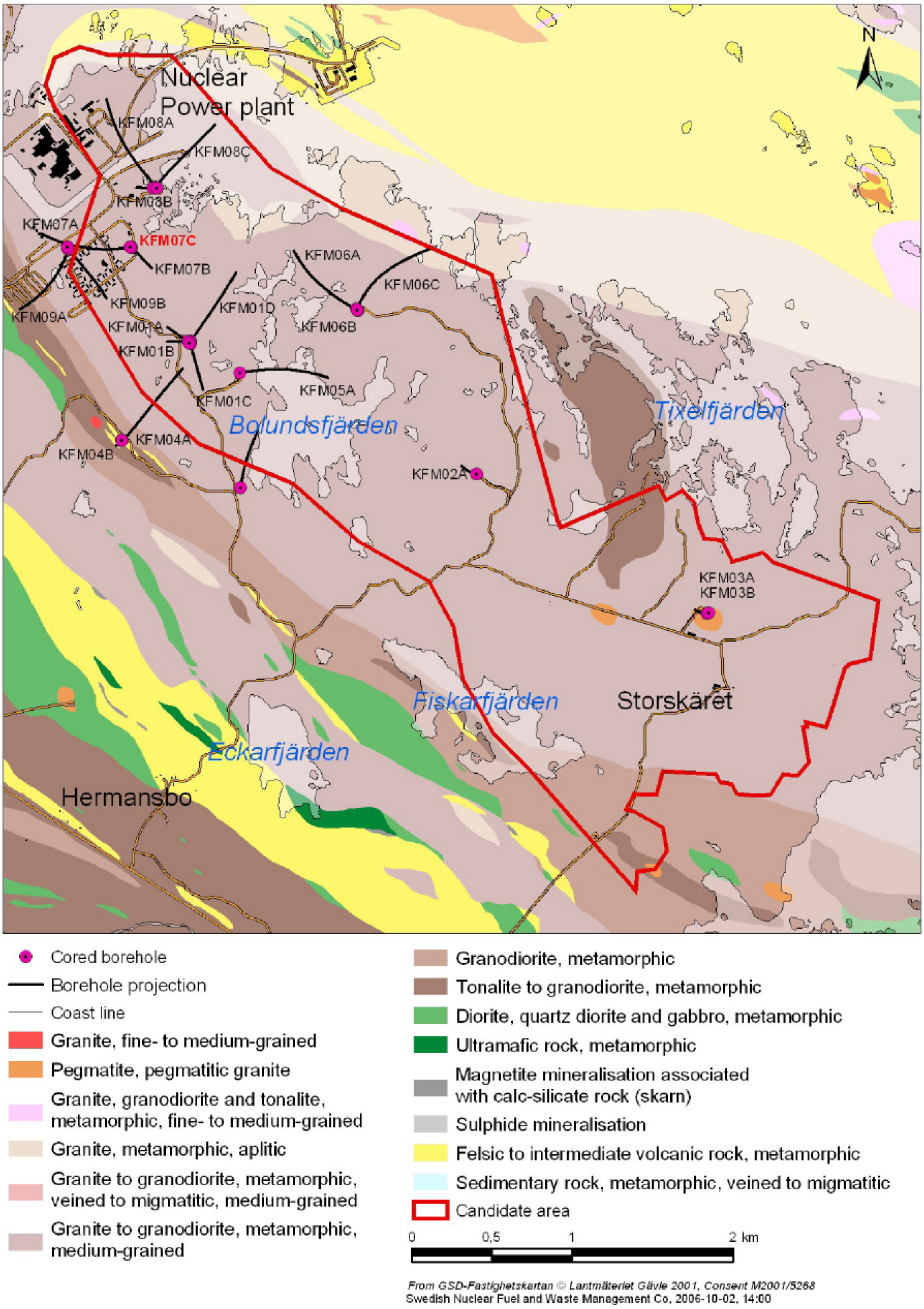

Figure 1-1. *Generalized geological map over Forsmark site investigation area and the projection of KFM07C in relation to other cored boreholes in the drilling programme.*

2 Objective and scope

The bedrock starts at 3.55 metres length in borehole KFM07C. The borehole starts with percussion drilling to a length of 85.15 metres, followed by core drilling at Ø = 86.0 mm to a length of 98.42 metres, and at Ø = 75.8 mm down to full its length at 500.34 metres. The diameter of the drill core obtained by overcoring is generally 61.4–61.9 mm, with a few cores at Ø = 51 mm. The drill core obtained from other intervals is 51 mm, under ideal conditions. Only the core drilled part of the borehole is included in the mapping engagement and the BIPS-image usable for geological logging covers the length interval 98.46–497.56 metres (after adjustment 98.46–498.46 metres). Thus, remaining part of the drill core, from 85.21 to 98.40 metres (identical lengths after adjustment) and from 498.46 to 499.31 (after adjustment 498.46–500.21 metres), was mapped by Boremap without any complementary BIPS-image.

An unstable section in the length interval at 428.30–430.28 metres was mechanically reinforced with the PLEX system (see Figure 3-7 in /Claesson and Nilsson 2005/). The reinforcement screens the borehole wall in the BIPS-image at the length interval 427.55–429.52 metres (after adjustment 428.34–430.30 metres). This is mapped as ‘core loss – mechanical’.

The aim of the geological borehole logging is to obtain a detailed documentation of *all* structures and lithologies in the interval that was core drilled. 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. 3.754. 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 415 metres drill core obtained from the interval 81.15–500.34 metres of KFM07C 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 KFM07C 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. Most of the mapping was done by two geologists at a time, forming a core logging team. One of the geologists did the core logging while the other registered the information in Boremap.

The core logging of KFM07C was performed in Boremap v. 3.754 according to activity plan AP PF 400-06-060 (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), except for that no generalised geophysical logs were available during the mapping.

A WellCAD summary of the mapping is presented in Appendix 1.

4.2 Preparations

The length recorded in the BIPS-image deviates from the true borehole length with increasing depth, and the difference at the bottom of the borehole is about 0.9 metres. Following the procedure used for all deep boreholes in the SKB's drilling programme, the length in KFM07C was adjusted with reference to groove millings cut into the borehole wall at every 50 metres, with the deepest slot at 450 metres length. The precise level of each reference mark can be found in SKB's database SICADA (Appendix 4). The BIPS-image used for the geological mapping down to about 420 metres length, was produced before completion of the borehole and lacks, consequently, the slots. Slot lengths were instead taken from a second BIPS-image, which covers more or less the entire cored interval. This second image was used for the geological mapping of the last 80 metres of KFM07C. However, the adjusted length may still deviate from the numbers given in the drill core boxes, as the core recovery may yield erroneous lengths. The difference does never exceed 0.5 decimetre. *All borehole lengths given in this report are adjusted with reference to the groove millings.*

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).

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.

In order to avoid that some broken fractures had not been registered, 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

A problem with the Boremap system is that certain geological features (mainly fractures) only can be observed 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 (see Section 4.5). 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. If possible, they are still oriented relative to other structures with known orientations. 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 mm. Thus, reliable measurements of fracture widths/apertures less than 1 mm are possible to obtain in the drill core. The minimum width/aperture given is therefore 0.5 mm, in accordance with the nomenclature for Boremap mapping (SKB MD 143.008; v. 1.0).

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 or the following treatment of the core. 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 nomenclature for Boremap mapping (SKB MD 143.008; v. 1.0).

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, occurs consistently as extremely thin coatings or impurities in other fracture minerals, such as adularia and laumontite.

Drill induced crushes have been registered at the two following intervals in KFM07C: 191.24–191.59 and 302.72–303.11 metres adjusted length. Both these intervals occur in overcoring sections affected by ring-discing. Also an interval of registered core loss at 170.26–170.68 metres adjusted length is associated with ring-discing.

4.5 Nonconformities

A few fractures within KFM07C 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, laumontite-bearing fractures suspected to have broken up in the drill core boxes 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 underrepresented in unbroken fractures.

In contrast to previous cored boreholes, there is virtually no brownish black coating at the borehole wall of KFM07C. However, the mapping was locally hampered by drill cuttings that obscure the lower 180° of the borehole wall. The problem is restricted to the length interval at 160–350 metres and from 415 metres to the end of the BIPS-image. Only high contrast features are distinguishable through the drill cuttings.

Both during the mapping and the subsequent work with mapping data from other boreholes in the drilling programme, we have noted a few inexplicable errors in the databases. No such errors have been observed for KFM07C, though there might still be unnoticed errors. We disclaim the responsibility for all errors caused by the shortcomings in the software.

After data export to the SKB database SICADA, it turned out that the length adjustment of the BIPS-image with reference to the reference marks in KFM07C, was incorrect. Consequently, the BIPS-image was readjusted 20 November 2006. The corrected data was exported to SICADA 28 November 2006.

5 Results

5.1 Lithology

5.1.1 General

Borehole KFM07C is located in the northwestern part of the site investigation area and plunges 85° towards southeast. The entire borehole occurs within the tectonic lens, which is equivalent to rock domain 29 /cf SKB 2005/. The predominant rock type in KFM07C is a medium-grained metagranite (rock code 101057), which also prevails in the previously drilled boreholes located in rock domain 29. Other frequent rock units within the borehole, none forming occurrences more than a few metres in length, include pegmatitic granites (rock code 101061) and amphibolites (rock code 102017). In addition, there are a few noteworthy occurrences of fine- to medium-grained metagranitoids (rock code 101051), intermediate metavolcanic rocks (rock code 103076) and one occurrence of medium-grained metagabbro (rock code 101033). Except for a few minor late veins or dykes, all rocks have experienced Svecofennian metamorphism under amphibolite facies conditions.

5.1.2 Rock types

The medium-grained metagranite (rock code 101057) 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 ranges from greyish red to grey. In addition, there are two minor occurrences, which are clearly granodioritic at 91.42–91.49 and 489.99–490.84 metres adjusted length. Both are mapped as medium-grained metagranodiotite (rock code 101056). Minor intervals speckled by fine-grained, whitish plagioclase occur sporadically in the metagranite. The general impression is that the feature is related to static recrystallization. Microscopic examination of similar rocks from KFM01A and KFM03A suggests that it is a result of retrograde sericitization /Petersson et al. 2004/.

Dykes, veins and segregations of pegmatite and pegmatitic granite are frequent throughout KFM07C. Most occurrences are some decimetre or less, but several pegmatites/pegmatitic granites exceed a few metres in borehole length. The two most extensive occurrences, at 218.8–223.4 and 330.2–335.4 metres adjusted length, reach approximately five metres in borehole length. 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, up to about one centimetre in diameter, has been identified in some pegmatites. Various sulphide minerals (primarily pyrite), as well as minor amount of garnet crystals are found more rarely. Despite the textural variability and temporal span within this unit, most of these rocks were grouped as 'pegmatite, pegmatitic granite' (rock code 101061). Quartz-dominated segregations or veins were coded as 8021. Some of them are sulphide-bearing with impregnations of pyrite, chalcopyrite and/or pyrrhotite.

Amphibolites (rock code 102017) occur sporadically throughout KFM07C. The most extensive occurrence occupies the interval 428.0–434.0. The upper 2.6 metres of the occurrence is medium-grained and slightly more hornblende/biotite-rich. It is, therefore, registered as medium-grained metagabbro (rock code 101033). None of the other amphibolite occurrences exceed two metres in borehole length. Texturally and mineralogically, the amphibolites form a rather heterogeneous group. However, the majority is fine-grained, equigranular with a large proportion of biotite. Extensions and contacts of the amphibolites are more or less parallel with the tectonic fabric. Some occurrences are surrounded by up to two decimetres wide rims of bleached wall rock, inferred to be the result of albitization. A few occurrences are clearly disconnected from amphibolites. The most extensive occurs at 136.4–137.2 metres adjusted length. The bleaching is evidently pre- or syn-metamorphic with no relationship to existing brittle structures. All these bleached intervals are registered as albitization. The relative intensity of the albitization is mainly based on the degree of whiteness of the feldspars for 'faint' to 'weak' intensities, and the textural obliteration for 'medium' to 'strong' intensities.

Four occurrences of fine- to medium-grained metagranitoids (rock code 101051) of granodioritic to tonalitic composition occur in KFM07C. Individual occurrences range up to 1.9 metres in borehole length. These rocks are equigranular, locally slightly porphyritic and ranges from grey to reddish grey in colour. The mineral fabric is commonly linear and external contacts are typically discordant to the tectonic foliation in the wall rock. A minor occurrence of fine- to medium-grained granite (rock code 111058), which is highly reminiscent of the fine-to medium-grained metagranitoid, occurs at 166.74–166.81 metres adjusted length in the borehole.

Intermediate rocks of inferred volcanic origin (rock code 103076) are present as minor occurrences, restricted to the interval 207.5–216.6 metres adjusted length. Individual occurrences range up to approximately one metre in borehole length. The rock is generally equigranular, dark grey in colour and all contacts are parallel with the tectonic fabric. There are no textural or structural macroscopic features that unambiguously points towards a volcanic origin of the rocks.

Some minor occurrences of aliptic metagranite occur sporadically throughout the borehole. Most occurrences are some decimetre or less in borehole length, but a few range up to 6 decimetres.

5.2 Ductile structures

Most rocks in KFM07C are characterized by composite L-S fabrics, with a general predominance of tectonic foliations. However, there are intervals with a more distinct mineral lineation. Some of the pegmatitic granites, the fine- to medium-grained metagranitoid (rock code 101051) and an occurrence of fine to medium-grained granite (rock code 111058) are post-tectonic with respect to the main tectonic foliation, and are consequently massive or show only a faint to weak mineral lineation.

The intensity of the deformational fabric in KFM07C is generally weak, and more rarely faint or medium. It must be emphasized, however, that the distinctness of a fabric does not necessarily reflect the intensity of the strain. The fact that a rock may appear massive does not always implicate that they actually are unaffected by strain. It is, for example, often difficult to distinguish tectonic fabric visually in the pegmatitic granites and some of the fine-grained mafic rocks. The orientation of the mineral fabric in KFM07C is rather constant throughout the borehole and registered foliations are consistently striking SSE and dip moderately (55–75°) towards west (Figure 5-1). None of the linear fabrics have been possible to register with the present methodology, but the general estimations indicate that they are gently to moderately dipping.

Totally four narrow zones of more intense ductile and brittle-ductile deformation have been registered in KFM07C. Three of them are registered as ductile shear zones and one as a brittle-ductile shear zone. The zones occur at the following intervals: 124.84–124.88, 187.16–187.25, 206.92–206.99 and 294.14–294.23 metres adjusted length. None of the zones exceed one decimetre in borehole length. The ductile deformation is generally characterized by intense grain-size reduction and the inferred protolith seems to be the medium-grained metagranite (rock code 101057). The brittle-ductile deformation zone, on the other hand, coincides with a hydrothermal quartz vein (rock code 8021). All four shear zones in KFM07C are more or less parallel with the local tectonic foliation (Figure 5-1).

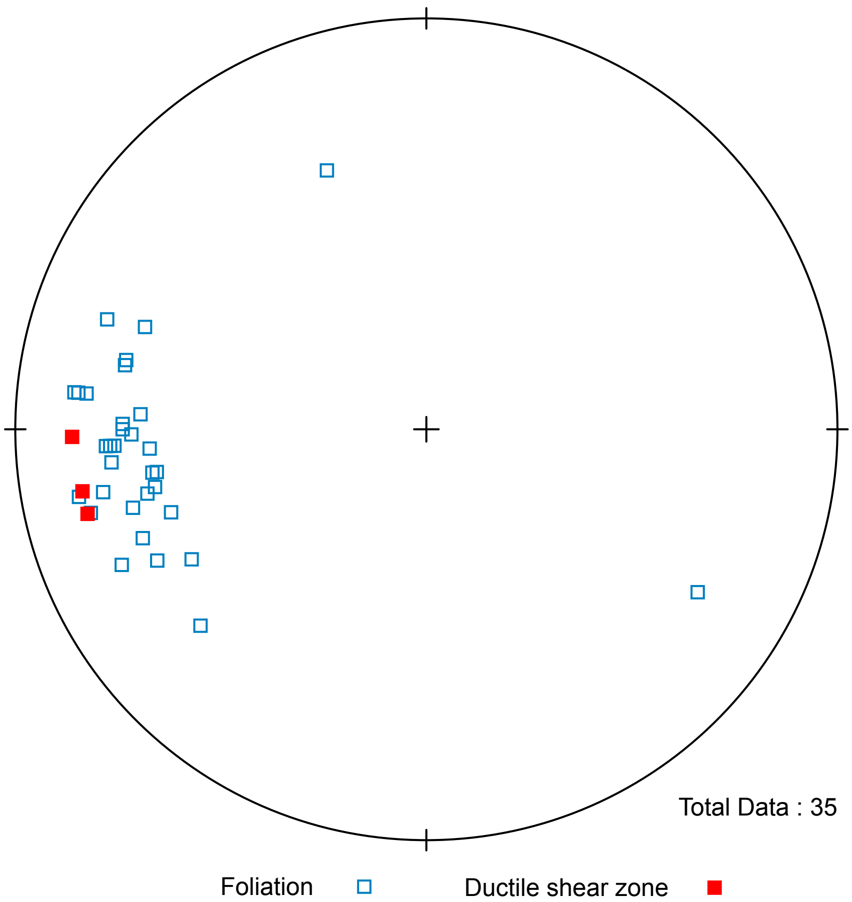

Figure 5-1. *Lower hemisphere, equal area stereographic projection showing poles to ductile structures in KFM07C.*

5.3 Alteration

Except for the albitization, which mainly occurs adjacent to amphibolites as discussed in Section 5.1, the most common alteration encountered in KFM07C is varying degrees of oxidation or red pigmentation of feldspars by sub-microscopic hematite. It is generally associated with more intensely fractured intervals and the most extensive interval occurs between 347 and 389 metres. Totally, about 12% of the mapped interval of KFM07C has been affected by oxidation. Normally this oxidation is faint to weak in intensity, and more rarely medium.

Other types of alterations within KFM07C are rather sparse, but include chloritization, laumontization, epidotization and an alteration that gives the rock a sligthy darker, blurred appearance (mapped as 'sassuritization' in Boremap). The chloritization is mainly restricted to amphibolites (rock code 102017), with the major occurrence in the metagabbro/amphibolite at 428.0–434.0 metres adjusted length. The laumontization is intimately associated with laumontite-sealed fracture networks in the length interval 347–380 metres, whereas the epidotization has affected three amphibolite-hosted pegmatite veins (rock code 101061), as well as an interval of brecciation.

5.4 Fractures

5.4.1 Fracture frequencies and orientations

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 *outside crush zones and sealed networks* during the Boremap-logging of KFM07C amounts to 1,924, i.e. about 4.6 fractures/metres. Of these are 304 open, 49 partly open and 1,571 sealed. This separation in open, partly open or sealed fractures is made on the basis of the weathering of the fracture surface and the fit of the fracture planes. It should be emphasized that there is a certain degree of uncertainty in these judgements.

In addition, there are 51 sealed networks, seven breccias (or brecciated intervals) and one cataclasite registered in the mapped interval. The distinction between breccia/cataclasite 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. Breccias and cataclasites, on the other hand, are distinguished by their volumetric content of matrix; occurrences with more than 90% matrix have been mapped as cataclasite. Significant fractures that differ markedly (e.g. in aperture or infilling mineralogy) from the majority of fractures within the sealed networks are mapped separately. The total length of all sealed networks in KFM07C amount to 10.7 metres (i.e. about 2.6% of the mapped interval). The piece length (i.e. the distance between individual fractures) within these networks is typically about 1.3 cm, but ranges up to 3 cm. This makes slightly more than 800 additional sealed fractures in the mapped interval of the borehole. Breccias are restricted to the length interval 307–380 metres. Except for a ca 2 dm wide zone at 349.16–349.38 metres adjusted length, they are all less than 1 dm wide. The cataclasite occurs in an amphibolite at 102.54–102.56 metres adjusted length. In addition to the breccias and cataclasite, there are eight individual fractures with measurable displacements registered in KFM07C.

Totally three crush zones occur in KFM07C, two in the length interval 92.27–92.86 and a third at 429.45–429.86 metres adjusted length. The average piece length in these intervals ranges up 2.5 cm.

Throughout the borehole, the frequency of open and sealed fractures varies rather coherently, with an increased number of open fractures in intervals with high concentrations of sealed fractures (Appendix 1). Generally, there are two major intervals with increased fracture frequency relative to the remaining part of the borehole. The most extensive length interval occurs between 308 and 387 metres. A low intersection angle between the borehole and some of the major fractures in this interval does, however, suggest that the actual width of the fractured zone is considerably less. It is dominated by sealed fractures and the majority of all sealed fracture networks in the borehole occurs in this interval. The fracture frequency is highly variable within the interval and fracture apertures range up to 7 mm. A second, more well-defined interval occurs at 91–104 metres length. It is characterised by a marked increase in the frequency of both open and sealed fractures.

It is reasonable to expect that mechanical discontinuities, such as lithological contacts, should be the locus of fracture formation more frequently than within 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 KFM07C are fractured. This can be compared with other cored boreholes from the Forsmark drilling programme, in which 22–42 % of the contacts are fractured /Petersson et al. 2006, and references therein/.

5.4.2 Fracture mineralogy

Chlorite and/or calcite are found in almost 80% of the total number of the registered fractures in KFM07C. Other infilling minerals, in order of decreasing abundance, include laumontite, adularia, quartz, pyrite, epidote, sub-microscopic hematite, clay minerals, and more rarely unspecified sulphides, prehnite, apophyllite (mapped as X1), analcime (mapped as X2), biotite, sericite and chalcopyrite. In addition, there are ten 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 44 fractures that are virtually free from visible mineral coatings. Nineteen of them are sealed fractures with no *visible* mineral sealing.

The various clay minerals occur generally in open fractures. Fractures with clay minerals are found throughout the borehole, but are generally more abundant in the major intervals with increased fracture frequency. Clay minerals registered in fractures at greater depths are typically corrensite and illite, often intimately associated with chlorite.

Sulphides are frequent in both open and sealed fractures. The presence of other sulphide minerals than pyrite, such as 'unspecified sulphides' and chalcopyrite, are rare and restricted to eleven fractures. Also hematite shows a rather even distribution between open and sealed fractures. It 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.

All other minerals, as well as oxidized walls, are preferentially associated with fractures inferred to be sealed. A typical mineral assemblage, commonly found both in individual fractures and sealed fracture networks consists of laumontite together with varying amounts of calcite, chlorite and locally adularia. Except for a few fractures at around 100 m length, the laumontite-bearing assemblage is restricted to borehole lengths over 270 metres. Another frequent assemblage, found throughout the borehole, is dominated by adularia and, subordinately, calcite, chlorite and locally epidote, quartz or laumontite.

Fractures with epidote are mostly concentrated to well-defined intervals within amphibolites (e.g. at 189.1–189.9, 193.6–193.9 and 411.8–412.2 metres), as well as a major interval at 456–474 metres length. Inferred prehnite is registered in ten fractures, of which eight are chlorite-dominated.

5.5 Core discing

Inferred core discing occurs mainly as ring discing in the cylindrical cores in intervals where overcoring has been done. Core discing outside intervals of overcoring are limited to nine minor occurrences, distributed at the following borehole lengths: 102.38–123.08, 275.52–294.50, 320.54–320.62, 357.47–357.51 and 492.25–492.30 metres. Except for a few separate ring discs, there are 41 distinct sections of ring discing registered in KFM07C. Virtually none of the pilot cores in the intervals with ring discing have been affected.

Some of the core and ring discing are initial and do not actually break the core. The maximum width of the intervals is approximately 7 dm. The typical dimension of individual ring discs range between 7 and 15 mm, whereas the dimension of individual core discs range between 12 and 25 mm. Most discs are essentially planar. However, some of the core discs are slightly saddle-shaped.

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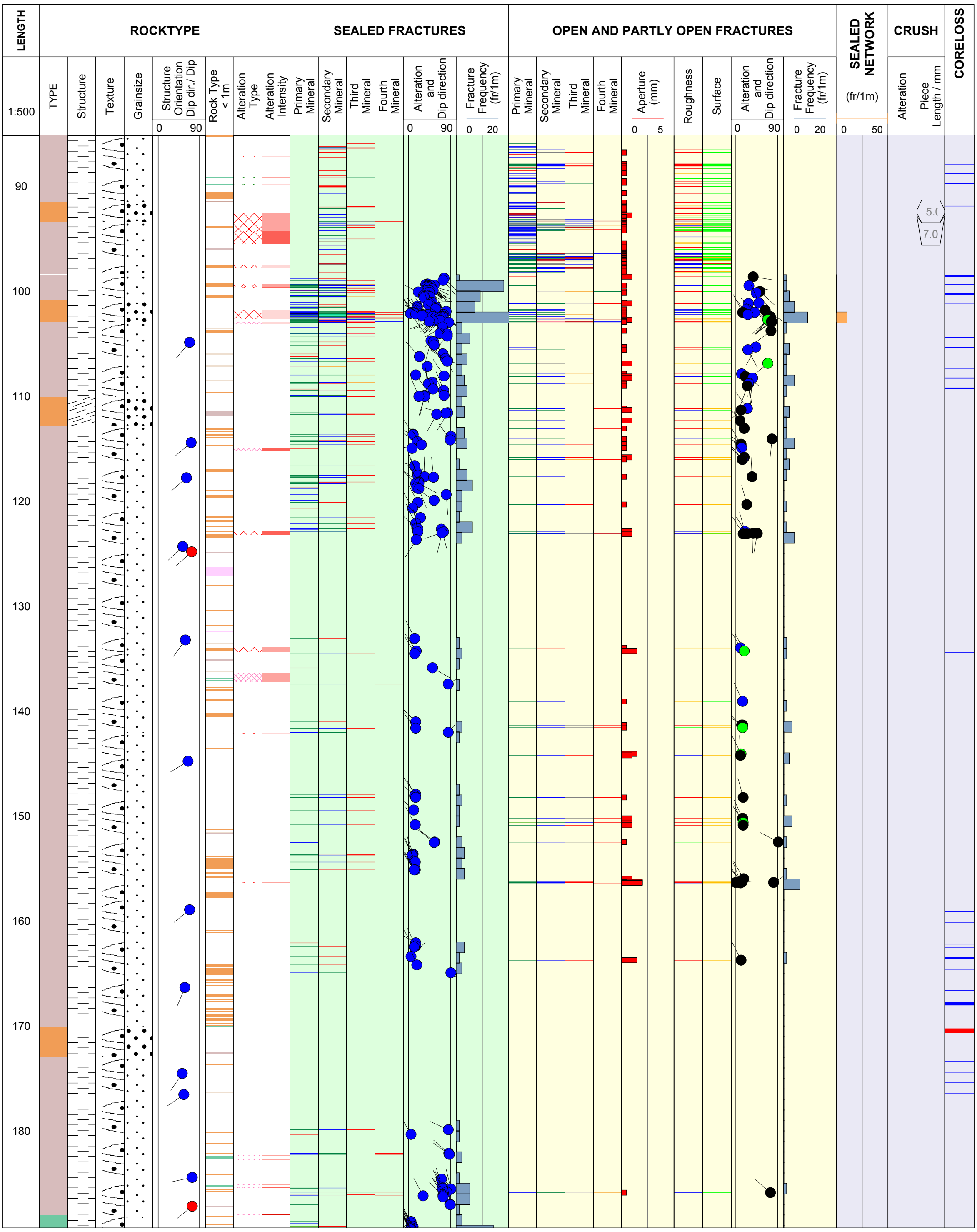
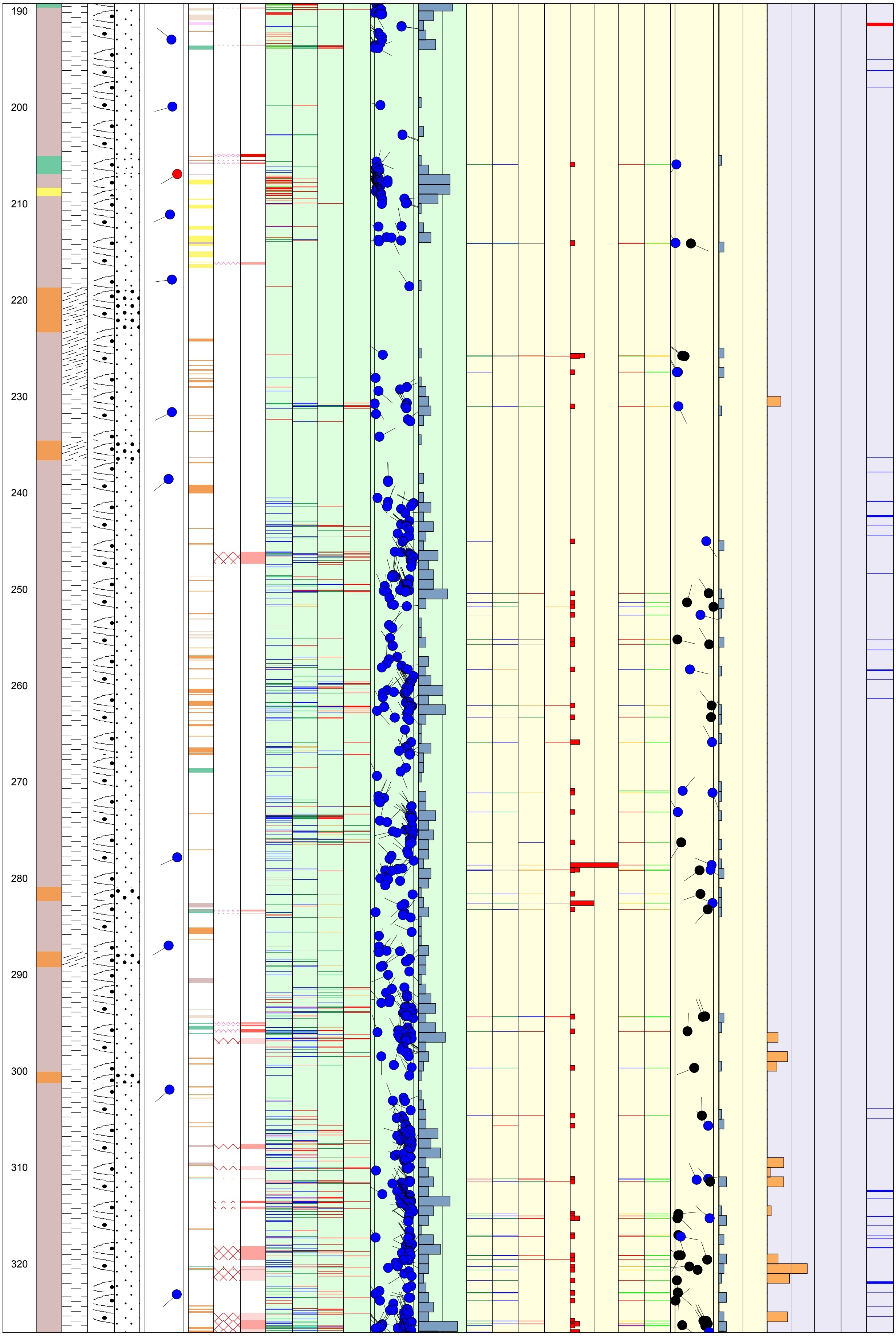
Appendix 1

WellCAD image

Title GEOLOGY IN KFM07C **Appendix: 1**

Site	FORSMARK	**Coordinate System**	RT90-RHB70
Borehole	KFM07C	**Northing [m]**	6700125.61
Diameter [mm]	76	**Easting [m]**	1631034.45
Length [m]	500.340	**Elevation [m.a.s.l.]**	3.35
Bearing [°]	142.71	**Drilling Start Date**	2005-12-20 14:30:00
Inclination [°]	-85.39	**Drilling Stop Date**	2006-01-17 13:00:00
Date of coremapping	2006-09-04 09:21:00	**Plot Date**	2006-12-07 22:13:42
Rocktype data from	p_rock	**Signed data**	

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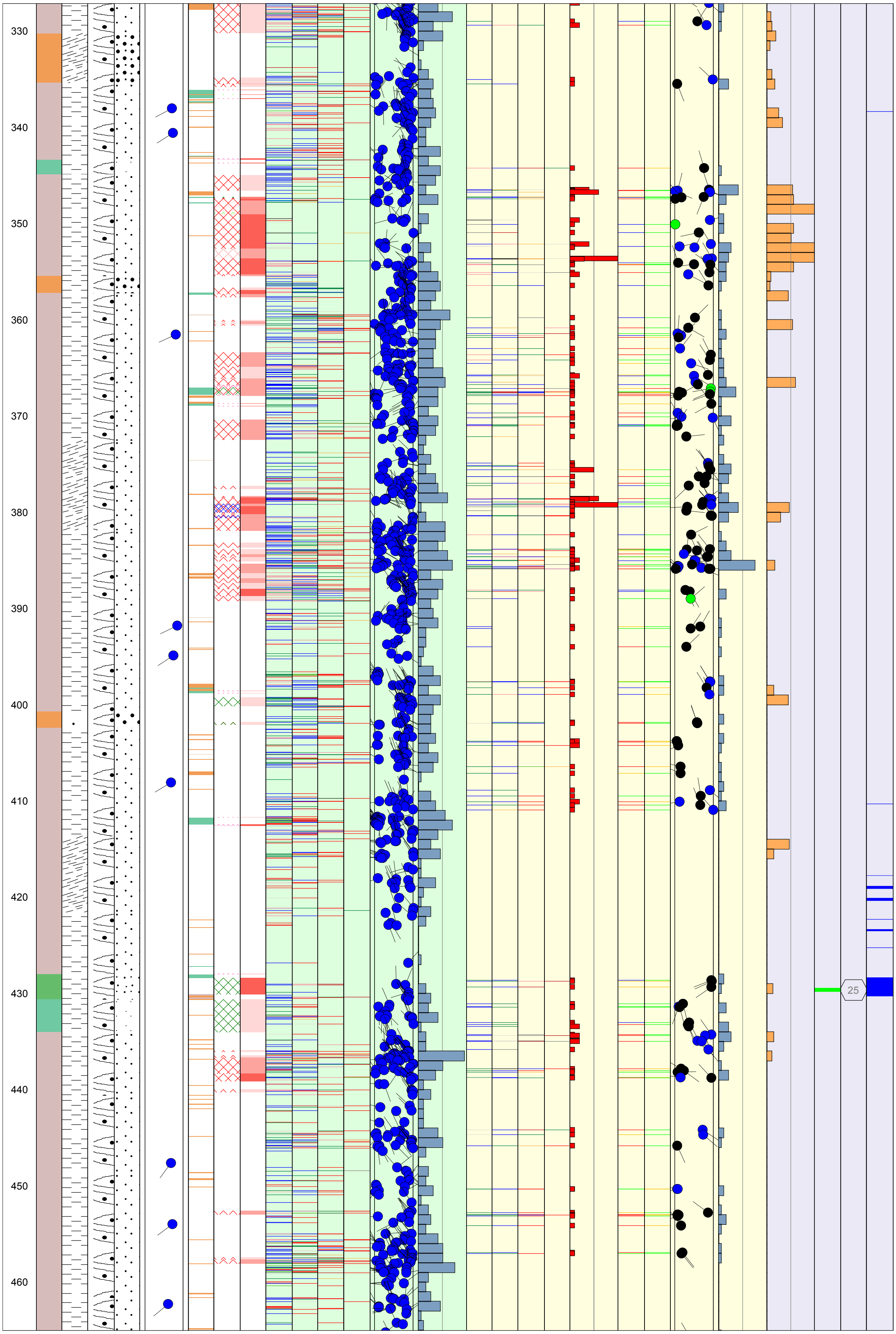
290
300
310
320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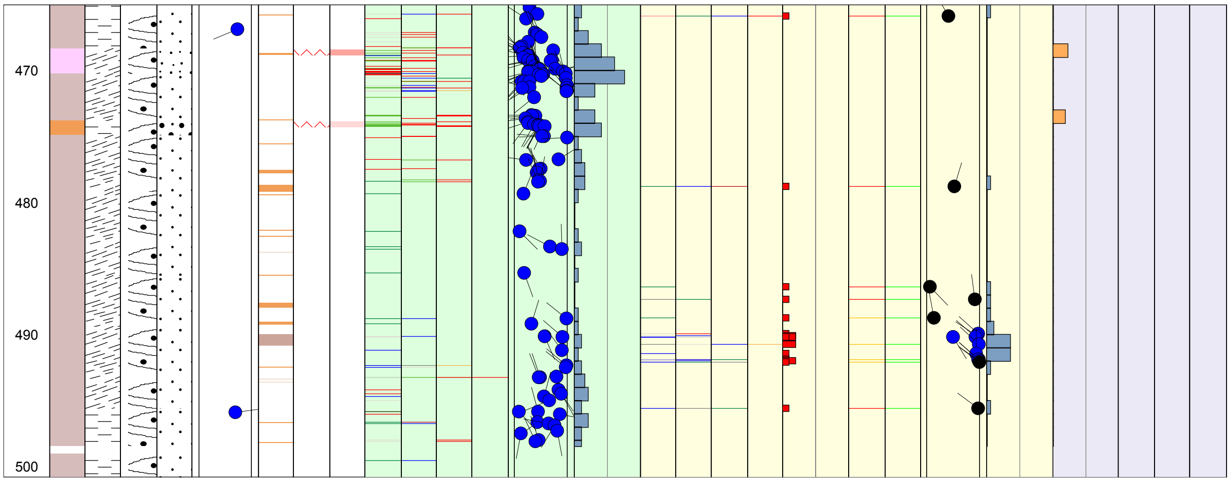
350
360
370
380
390
400
410
420
430
440
450
460
25



470
480
490
500

Appendix 2

Borehole diameters

Hole Diam T – Drilling: Borehole diameter

KFM07C, 2006-03-30 00:00:00–2006-08-08 00:00:00 (85.150–500.340 m).

Sub Secup (m)	Sub Seclow (m)	Hole Diam (m)	Comment
85.150	98.420	0.0860	
98.420	500.340	0.0758	
428.200	430.400	0.0840	Rymning för PLEX

Printout from SICADA 2006-10-02 13:15:23.

Appendix 3

Downhole deviation measurements

Maxibor T – Borehole deviation: Maxibor

KFM07C, 2006-08-09 14:00:00–2006-08-09 20:00:00 (3.000–498.000 m).

Length (m)	Northing (m)	Easting (m)	Elevation (m)	Coord System	Inclination (degrees)	Bearing (degrees)	Local A (m)	Local B (m)	Local C (m)
3.00	6700125.42	1631034.60	–0.36	RT90-RHB70	–85.40	142.71	0.0000	0.0000	0.0000
6.00	6700125.23	1631034.75	2.63	RT90-RHB70	–85.32	143.80	0.2400	0.0000	0.0000
9.00	6700125.03	1631034.89	5.62	RT90-RHB70	–85.26	144.31	0.4900	0.0000	0.0000
12.00	6700124.83	1631035.04	8.61	RT90-RHB70	–85.24	145.01	0.7300	0.0100	0.0100
15.00	6700124.63	1631035.18	11.60	RT90-RHB70	–85.24	145.45	0.9800	0.0200	0.0200
18.00	6700124.42	1631035.32	14.59	RT90-RHB70	–85.20	145.77	1.2300	0.0300	0.0300
21.00	6700124.21	1631035.46	17.58	RT90-RHB70	–85.19	146.09	1.4800	0.0500	0.0400
24.00	6700124.00	1631035.60	20.57	RT90-RHB70	–85.12	146.10	1.7300	0.0600	0.0500
27.00	6700123.79	1631035.74	23.56	RT90-RHB70	–85.08	146.30	1.9900	0.0800	0.0600
30.00	6700123.58	1631035.89	26.55	RT90-RHB70	–84.99	146.29	2.2400	0.0900	0.0800
33.00	6700123.36	1631036.03	29.53	RT90-RHB70	–84.94	147.02	2.5100	0.1100	0.1000
36.00	6700123.14	1631036.17	32.52	RT90-RHB70	–84.91	147.68	2.7700	0.1300	0.1200
39.00	6700122.91	1631036.32	35.51	RT90-RHB70	–84.92	148.09	3.0300	0.1500	0.1500
42.00	6700122.69	1631036.46	38.50	RT90-RHB70	–84.94	148.58	3.3000	0.1800	0.1700
45.00	6700122.46	1631036.60	41.49	RT90-RHB70	–84.90	148.77	3.5600	0.2000	0.1900
48.00	6700122.23	1631036.73	44.48	RT90-RHB70	–84.88	149.34	3.8300	0.2300	0.2200
51.00	6700122.00	1631036.87	47.46	RT90-RHB70	–84.85	149.07	4.0900	0.2600	0.2400
54.00	6700121.77	1631037.01	50.45	RT90-RHB70	–84.82	148.62	4.3600	0.2900	0.2700
57.00	6700121.54	1631037.15	53.44	RT90-RHB70	–84.80	147.84	4.6300	0.3200	0.3000
60.00	6700121.31	1631037.29	56.43	RT90-RHB70	–84.68	148.74	4.9000	0.3500	0.3300
63.00	6700121.07	1631037.44	59.41	RT90-RHB70	–84.49	151.13	5.1800	0.3700	0.3700
66.00	6700120.82	1631037.58	62.40	RT90-RHB70	–84.37	152.06	5.4600	0.4200	0.4100
69.00	6700120.56	1631037.72	65.39	RT90-RHB70	–84.44	152.14	5.7500	0.4600	0.4600
72.00	6700120.30	1631037.85	68.37	RT90-RHB70	–84.53	151.33	6.0400	0.5100	0.5100
75.00	6700120.05	1631037.99	71.36	RT90-RHB70	–84.49	151.27	6.3200	0.5500	0.5500
78.00	6700119.80	1631038.13	74.34	RT90-RHB70	–84.38	151.80	6.6100	0.6000	0.5900
81.00	6700119.54	1631038.27	77.33	RT90-RHB70	–84.35	151.95	6.9000	0.6400	0.6400
84.00	6700119.28	1631038.40	80.32	RT90-RHB70	–84.45	151.74	7.1900	0.6900	0.7000
87.00	6700119.03	1631038.54	83.30	RT90-RHB70	–84.28	152.07	7.4800	0.7400	0.7400
90.00	6700118.76	1631038.68	86.29	RT90-RHB70	–84.24	151.91	7.7700	0.7900	0.8000
93.00	6700118.50	1631038.82	89.27	RT90-RHB70	–84.20	151.49	8.0700	0.8300	0.8500
96.00	6700118.23	1631038.97	92.26	RT90-RHB70	–84.14	151.68	8.3700	0.8800	0.9100
99.00	6700117.96	1631039.11	95.24	RT90-RHB70	–84.15	151.51	8.6700	0.9300	0.9700
102.00	6700117.69	1631039.26	98.22	RT90-RHB70	–84.17	151.56	8.9700	0.9700	1.0400
105.00	6700117.42	1631039.40	101.21	RT90-RHB70	–84.18	151.70	9.2700	1.0200	1.1000
108.00	6700117.16	1631039.55	104.19	RT90-RHB70	–84.17	151.64	9.5700	1.0700	1.1600
111.00	6700116.89	1631039.69	107.18	RT90-RHB70	–84.16	151.84	9.8700	1.1200	1.2200
114.00	6700116.62	1631039.84	110.16	RT90-RHB70	–84.17	151.72	10.1800	1.1600	1.2800
117.00	6700116.35	1631039.98	113.15	RT90-RHB70	–84.17	151.68	10.4800	1.2100	1.3400

Length (m)	Northing (m)	Easting (m)	Elevation (m)	Coord System	Inclination (degrees)	Bearing (degrees)	Local A (m)	Local B (m)	Local C (m)
120.00	6700116.08	1631040.13	116.13	RT90-RHB70	–84.18	151.37	10.7800	1.2600	1.4000
123.00	6700115.82	1631040.27	119.12	RT90-RHB70	–84.17	151.26	11.0800	1.3100	1.4600
126.00	6700115.55	1631040.42	122.10	RT90-RHB70	–84.18	151.18	11.3800	1.3500	1.5200
129.00	6700115.28	1631040.57	125.09	RT90-RHB70	–84.17	151.14	11.6800	1.4000	1.5800
132.00	6700115.01	1631040.71	128.07	RT90-RHB70	–84.18	151.20	11.9800	1.4400	1.6400
135.00	6700114.75	1631040.86	131.05	RT90-RHB70	–84.18	150.81	12.2800	1.4900	1.7000
138.00	6700114.48	1631041.01	134.04	RT90-RHB70	–84.19	150.56	12.5800	1.5300	1.7600
141.00	6700114.22	1631041.16	137.02	RT90-RHB70	–84.20	150.56	12.8800	1.5700	1.8200
144.00	6700113.95	1631041.31	140.01	RT90-RHB70	–84.21	150.62	13.1800	1.6100	1.8800
147.00	6700113.69	1631041.45	142.99	RT90-RHB70	–84.23	150.58	13.4800	1.6500	1.9400
150.00	6700113.43	1631041.60	145.98	RT90-RHB70	–84.23	150.58	13.7800	1.6900	2.0000
153.00	6700113.17	1631041.75	148.96	RT90-RHB70	–84.23	150.81	14.0800	1.7400	2.0600
156.00	6700112.90	1631041.90	151.95	RT90-RHB70	–84.25	150.66	14.3800	1.7800	2.1200
159.00	6700112.64	1631042.05	154.93	RT90-RHB70	–84.24	150.55	14.6800	1.8200	2.1800
162.00	6700112.38	1631042.19	157.92	RT90-RHB70	–84.25	150.58	14.9800	1.8600	2.2300
165.00	6700112.12	1631042.34	160.90	RT90-RHB70	–84.25	150.37	15.2700	1.9000	2.2900
168.00	6700111.85	1631042.49	163.89	RT90-RHB70	–84.24	150.31	15.5700	1.9400	2.3500
171.00	6700111.59	1631042.64	166.87	RT90-RHB70	–84.26	150.22	15.8700	1.9800	2.4100
174.00	6700111.33	1631042.79	169.86	RT90-RHB70	–84.25	149.99	16.1700	2.0200	2.4700
177.00	6700111.07	1631042.94	172.84	RT90-RHB70	–84.23	149.97	16.4700	2.0600	2.5200
180.00	6700110.81	1631043.09	175.83	RT90-RHB70	–84.21	149.68	16.7700	2.1000	2.5800
183.00	6700110.55	1631043.24	178.81	RT90-RHB70	–84.19	149.35	17.0700	2.1300	2.6400
186.00	6700110.29	1631043.40	181.80	RT90-RHB70	–84.19	149.37	17.3700	2.1700	2.7000
189.00	6700110.03	1631043.55	184.78	RT90-RHB70	–84.20	149.72	17.6700	2.2000	2.7600
192.00	6700109.77	1631043.70	187.76	RT90-RHB70	–84.21	149.93	17.9700	2.2400	2.8300
195.00	6700109.50	1631043.86	190.75	RT90-RHB70	–84.22	149.77	18.2700	2.2800	2.8900
198.00	6700109.24	1631044.01	193.73	RT90-RHB70	–84.21	149.70	18.5700	2.3200	2.9400
201.00	6700108.98	1631044.16	196.72	RT90-RHB70	–84.21	149.63	18.8700	2.3500	3.0000
204.00	6700108.72	1631044.31	199.70	RT90-RHB70	–84.19	149.19	19.1700	2.3900	3.0600
207.00	6700108.46	1631044.47	202.69	RT90-RHB70	–84.18	149.14	19.4700	2.4200	3.1300
210.00	6700108.20	1631044.63	205.67	RT90-RHB70	–84.20	149.39	19.7800	2.4600	3.1900
213.00	6700107.94	1631044.78	208.66	RT90-RHB70	–84.21	149.83	20.0800	2.4900	3.2500
216.00	6700107.68	1631044.93	211.64	RT90-RHB70	–84.20	150.55	20.3800	2.5300	3.3100
219.00	6700107.41	1631045.08	214.63	RT90-RHB70	–84.21	150.62	20.6800	2.5700	3.3700
222.00	6700107.15	1631045.23	217.61	RT90-RHB70	–84.21	150.50	20.9800	2.6100	3.4300
225.00	6700106.88	1631045.38	220.60	RT90-RHB70	–84.22	150.51	21.2800	2.6500	3.4900
228.00	6700106.62	1631045.53	223.58	RT90-RHB70	–84.23	150.33	21.5800	2.7000	3.5500
231.00	6700106.36	1631045.68	226.57	RT90-RHB70	–84.21	150.25	21.8800	2.7400	3.6100
234.00	6700106.10	1631045.83	229.55	RT90-RHB70	–84.21	150.18	22.1800	2.7800	3.6700
237.00	6700105.83	1631045.98	232.53	RT90-RHB70	–84.22	150.05	22.4800	2.8100	3.7300
240.00	6700105.57	1631046.13	235.52	RT90-RHB70	–84.22	150.10	22.7700	2.8500	3.7800
243.00	6700105.31	1631046.28	238.50	RT90-RHB70	–84.24	150.04	23.0700	2.8900	3.8400
246.00	6700105.05	1631046.43	241.49	RT90-RHB70	–84.23	149.74	23.3700	2.9300	3.9000
249.00	6700104.79	1631046.58	244.47	RT90-RHB70	–84.23	149.52	23.6700	2.9700	3.9600
252.00	6700104.53	1631046.73	247.46	RT90-RHB70	–84.23	149.55	23.9700	3.0000	4.0200
255.00	6700104.27	1631046.89	250.44	RT90-RHB70	–84.25	149.51	24.2700	3.0400	4.0800
258.00	6700104.01	1631047.04	253.43	RT90-RHB70	–84.25	149.63	24.5700	3.0700	4.1400
261.00	6700103.75	1631047.19	256.41	RT90-RHB70	–84.26	149.80	24.8700	3.1100	4.2000

Length (m)	Northing (m)	Easting (m)	Elevation (m)	Coord System	Inclination (degrees)	Bearing (degrees)	Local A (m)	Local B (m)	Local C (m)
264.00	6700103.49	1631047.34	259.40	RT90-RHB70	–84.28	149.63	25.1700	3.1500	4.2500
267.00	6700103.23	1631047.49	262.38	RT90-RHB70	–84.29	149.58	25.4600	3.1800	4.3100
270.00	6700102.98	1631047.64	265.37	RT90-RHB70	–84.31	149.46	25.7600	3.2200	4.3700
273.00	6700102.72	1631047.80	268.35	RT90-RHB70	–84.30	149.31	26.0500	3.2500	4.4200
276.00	6700102.46	1631047.95	271.34	RT90-RHB70	–84.29	149.32	26.3500	3.2900	4.4800
279.00	6700102.21	1631048.10	274.32	RT90-RHB70	–84.30	149.25	26.6500	3.3200	4.5300
282.00	6700101.95	1631048.25	277.31	RT90-RHB70	–84.30	149.10	26.9400	3.3600	4.5900
285.00	6700101.69	1631048.41	280.29	RT90-RHB70	–84.31	149.11	27.2400	3.3900	4.6400
288.00	6700101.44	1631048.56	283.28	RT90-RHB70	–84.31	149.01	27.5400	3.4200	4.7000
291.00	6700101.18	1631048.71	286.26	RT90-RHB70	–84.31	149.15	27.8300	3.4600	4.7500
294.00	6700100.93	1631048.86	289.25	RT90-RHB70	–84.32	148.96	28.1300	3.4900	4.8100
297.00	6700100.67	1631049.02	292.24	RT90-RHB70	–84.31	148.89	28.4200	3.5200	4.8600
300.00	6700100.42	1631049.17	295.22	RT90-RHB70	–84.32	148.99	28.7200	3.5500	4.9200
303.00	6700100.17	1631049.32	298.21	RT90-RHB70	–84.31	148.80	29.0100	3.5900	4.9700
306.00	6700099.91	1631049.48	301.19	RT90-RHB70	–84.30	148.80	29.3100	3.6200	5.0300
309.00	6700099.66	1631049.63	304.18	RT90-RHB70	–84.31	148.71	29.6000	3.6500	5.0900
312.00	6700099.40	1631049.79	307.16	RT90-RHB70	–84.30	148.69	29.9000	3.6800	5.1400
315.00	6700099.15	1631049.94	310.15	RT90-RHB70	–84.32	148.72	30.2000	3.7100	5.2000
318.00	6700098.89	1631050.10	313.13	RT90-RHB70	–84.33	148.47	30.4900	3.7400	5.2500
321.00	6700098.64	1631050.25	316.12	RT90-RHB70	–84.32	148.38	30.7900	3.7700	5.3100
324.00	6700098.39	1631050.41	319.10	RT90-RHB70	–84.32	148.20	31.0800	3.8000	5.3600
327.00	6700098.14	1631050.56	322.09	RT90-RHB70	–84.31	148.09	31.3800	3.8300	5.4200
330.00	6700097.88	1631050.72	325.07	RT90-RHB70	–84.29	148.15	31.6700	3.8600	5.4700
333.00	6700097.63	1631050.88	328.06	RT90-RHB70	–84.29	147.98	31.9700	3.8900	5.5300
336.00	6700097.38	1631051.04	331.04	RT90-RHB70	–84.30	147.90	32.2700	3.9100	5.5900
339.00	6700097.13	1631051.19	334.03	RT90-RHB70	–84.32	147.77	32.5600	3.9400	5.6400
342.00	6700096.87	1631051.35	337.01	RT90-RHB70	–84.32	147.74	32.8600	3.9700	5.7000
345.00	6700096.62	1631051.51	340.00	RT90-RHB70	–84.33	147.93	33.1600	3.9900	5.7500
348.00	6700096.37	1631051.67	342.98	RT90-RHB70	–84.35	147.81	33.4500	4.0200	5.8100
351.00	6700096.12	1631051.82	345.97	RT90-RHB70	–84.33	147.56	33.7400	4.0500	5.8600
354.00	6700095.87	1631051.98	348.96	RT90-RHB70	–84.31	147.67	34.0400	4.0700	5.9200
357.00	6700095.62	1631052.14	351.94	RT90-RHB70	–84.31	148.01	34.3400	4.1000	5.9700
360.00	6700095.37	1631052.30	354.93	RT90-RHB70	–84.29	148.09	34.6300	4.1200	6.0300
363.00	6700095.11	1631052.46	357.91	RT90-RHB70	–84.29	148.07	34.9300	4.1500	6.0800
366.00	6700094.86	1631052.62	360.90	RT90-RHB70	–84.28	148.13	35.2300	4.1800	6.1400
369.00	6700094.61	1631052.77	363.88	RT90-RHB70	–84.28	148.49	35.5300	4.2100	6.2000
372.00	6700094.35	1631052.93	366.87	RT90-RHB70	–84.29	148.60	35.8200	4.2400	6.2600
375.00	6700094.10	1631053.09	369.85	RT90-RHB70	–84.28	148.65	36.1200	4.2700	6.3100
378.00	6700093.84	1631053.24	372.84	RT90-RHB70	–84.27	148.73	36.4200	4.3000	6.3700
381.00	6700093.59	1631053.40	375.82	RT90-RHB70	–84.27	148.61	36.7200	4.3300	6.4300
384.00	6700093.33	1631053.55	378.81	RT90-RHB70	–84.27	148.44	37.0100	4.3600	6.4900
387.00	6700093.07	1631053.71	381.79	RT90-RHB70	–84.28	148.12	37.3100	4.3900	6.5400
390.00	6700092.82	1631053.87	384.78	RT90-RHB70	–84.27	147.64	37.6100	4.4200	6.6000
393.00	6700092.57	1631054.03	387.76	RT90-RHB70	–84.26	147.31	37.9100	4.4500	6.6600
396.00	6700092.32	1631054.19	390.75	RT90-RHB70	–84.25	147.02	38.2100	4.4700	6.7200
399.00	6700092.06	1631054.35	393.73	RT90-RHB70	–84.22	146.98	38.5100	4.4900	6.7800
402.00	6700091.81	1631054.52	396.72	RT90-RHB70	–84.22	146.88	38.8100	4.5200	6.8400
405.00	6700091.56	1631054.68	399.70	RT90-RHB70	–84.21	146.60	39.1100	4.5400	6.9000

Length (m)	Northing (m)	Easting (m)	Elevation (m)	Coord System	Inclination (degrees)	Bearing (degrees)	Local A (m)	Local B (m)	Local C (m)
408.00	6700091.30	1631054.85	402.69	RT90-RHB70	–84.21	146.43	39.4100	4.5600	6.9600
411.00	6700091.05	1631055.02	405.67	RT90-RHB70	–84.22	146.22	39.7100	4.5800	7.0200
414.00	6700090.80	1631055.19	408.65	RT90-RHB70	–84.21	146.16	40.0100	4.6000	7.0800
417.00	6700090.55	1631055.35	411.64	RT90-RHB70	–84.22	146.06	40.3200	4.6100	7.1400
420.00	6700090.30	1631055.52	414.62	RT90-RHB70	–84.22	146.02	40.6200	4.6300	7.2100
423.00	6700090.05	1631055.69	417.61	RT90-RHB70	–84.24	146.13	40.9200	4.6500	7.2700
426.00	6700089.80	1631055.86	420.59	RT90-RHB70	–84.26	146.12	41.2200	4.6700	7.3300
429.00	6700089.55	1631056.03	423.58	RT90-RHB70	–84.26	146.21	41.5200	4.6900	7.3900
432.00	6700089.30	1631056.19	426.56	RT90-RHB70	–84.27	146.24	41.8200	4.7000	7.4500
435.00	6700089.05	1631056.36	429.55	RT90-RHB70	–84.26	146.14	42.1200	4.7200	7.5000
438.00	6700088.80	1631056.53	432.53	RT90-RHB70	–84.27	146.10	42.4200	4.7400	7.5600
441.00	6700088.55	1631056.69	435.52	RT90-RHB70	–84.27	146.01	42.7200	4.7600	7.6200
444.00	6700088.30	1631056.86	438.50	RT90-RHB70	–84.28	146.02	43.0200	4.7800	7.6800
447.00	6700088.06	1631057.03	441.49	RT90-RHB70	–84.28	145.81	43.3100	4.7900	7.7400
450.00	6700087.81	1631057.20	444.47	RT90-RHB70	–84.27	145.62	43.6100	4.8100	7.8000
453.00	6700087.56	1631057.37	447.46	RT90-RHB70	–84.27	145.42	43.9100	4.8200	7.8600
456.00	6700087.32	1631057.54	450.44	RT90-RHB70	–84.25	145.33	44.2100	4.8400	7.9100
459.00	6700087.07	1631057.71	453.43	RT90-RHB70	–84.24	145.14	44.5100	4.8500	7.9700
462.00	6700086.82	1631057.88	456.41	RT90-RHB70	–84.24	144.92	44.8100	4.8600	8.0300
465.00	6700086.57	1631058.05	459.40	RT90-RHB70	–84.23	144.60	45.1100	4.8800	8.1000
468.00	6700086.33	1631058.23	462.38	RT90-RHB70	–84.22	144.34	45.4100	4.8900	8.1600
471.00	6700086.08	1631058.40	465.37	RT90-RHB70	–84.21	144.09	45.7200	4.8900	8.2200
474.00	6700085.84	1631058.58	468.35	RT90-RHB70	–84.19	143.98	46.0200	4.9000	8.2800
477.00	6700085.59	1631058.76	471.34	RT90-RHB70	–84.20	143.85	46.3200	4.9100	8.3400
480.00	6700085.35	1631058.94	474.32	RT90-RHB70	–84.22	143.78	46.6300	4.9100	8.4100
483.00	6700085.10	1631059.12	477.31	RT90-RHB70	–84.24	143.77	46.9300	4.9200	8.4700
486.00	6700084.86	1631059.29	480.29	RT90-RHB70	–84.25	143.66	47.2300	4.9300	8.5300
489.00	6700084.62	1631059.47	483.28	RT90-RHB70	–84.24	143.62	47.5300	4.9300	8.5900
492.00	6700084.38	1631059.65	486.26	RT90-RHB70	–84.25	143.72	47.8300	4.9400	8.6500
498.00	6700083.89	1631060.01	492.23	RT90-RHB70	–84.24	143.85	48.4300	4.9500	8.7700

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Appendix 4

Length reference marks

Reference Mark T – Reference mark in drillhole

KFM07C, 2006-08-09 07:30:00–2006-08-09 12:30:00 (150.000–450.000 m).

Bhlen (m)	Rotation Speed (rpm)	Start Flow (l/h)	Stop Flow (l/h)	Stop Pressure (bar)	Cutter Time (s)	Trace Detectable	Cutter Diameter (mm)
150.00	400.00	400	300	30.0	0	JA	150.27/150.37
200.00	400.00	400	300	30.0	0	JA	200.44/200.54
250.00	400.00	400	300	35.0	0	JA	250.62/250.72
300.00	400.00	400	300	35.0	1	JA	300.79/300.89
350.00	400.00	400	300	35.0	0	JA	351.02/351.12
400.00	400.00	450	300	35.0	0	JA	401.16/401.26
450.00	400.00	450	300	35.0	1	JA	451.46/451.56

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