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Abstract

This report presents the results from the Boremap logging of core drilled borehole KFM09B. The borehole is located in the camp area, south of the Forsmark nuclear power plant, with 60° inclination towards SE. The main purpose for the location of this borehole was to provide geological data for the design of access tunnels and the central area of a final repository. The full length of KFM09B is 616.45 metres. The BIPS-image usable for mapping covers the interval 9.22–612.37 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. The lowermost metres of the drill core were mapped in Boremap without any complementary BIPS-image.

KFM09B is drilled just inside the northwestern limit of the candidate area, along the ductile planar structures of rock domain 29. Most rock extensions and contacts in this domain are concordant with the planar deformational fabric, and the lithological variations within KFM09B are, therefore, rather limited. The predominant rock type in the borehole is a medium-grained metagranite, similar to that in the previously drilled deep boreholes located in the candidate area. Another important component is pegmatitic granite, which constitutes about one fourth of the mapped borehole interval. A concentration of skarn-like material, intimately associated with metagranite that has been variably affected by albitization, occurs in the length interval between 261 and 312 metres. Other rock units in KFM09B, none of which forming occurrences that exceed a few metres in borehole length, include amphibolites and fine- to medium-grained metagranitoids of granitic to granodioritic composition. Virtually all rocks in the borehole have experienced Svecofennian metamorphism under amphibolite facies conditions. An interval of vuggy, syenitic rock, formed as a result of selective quartz dissolution, occurs at 568.92–573.45 metres adjusted length.

Most rocks in KFM09B are characterized by composite L-S fabrics, with a strong predominance of tectonic foliations. Totally eight narrow zones of more intense ductile and brittle-ductile deformation have been registered in the borehole. The majority of the shear zones in KFM09B are steeply dipping and strikes roughly SSE (i.e. 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 KFM09B amounts to 3,495. Of these are 677 open, 84 partly open and 2,734 sealed. In addition, there are 148 sealed networks, 19 breccias (or brecciated intervals), three crush zones and two cataclasites registered in the mapped interval. The total length of all sealed networks in KFM09B amount to 22 metres (i.e. 3.7% of the mapped interval). Chlorite and calcite are the most frequent fracture filling minerals within KFM09B. A typical mineral assemblage, commonly found in fractures inferred to be sealed, consists of laumontite together with calcite, chlorite, and locally hematite, pyrite, quartz and adularia. Other, less common, but yet characteristic assemblages, mainly found in sealed fractures are epidote + calcite + chlorite ± quartz ± adularia and adularia + calcite + chlorite ± hematite ± quartz. The most frequent minerals, largely restricted to open fractures, are clay minerals and asphaltite. Pyrite and apophyllite are common in both sealed and open fractures.

Sammanfattning

Föreliggande rapport redovisar resultaten från Boremapkarteringen av kärnborrhål KFM09B. Borrhålet är beläget vid bostadsområdet söder om Forsmark kärnkraftverk och stupar 60° mot SO. Det huvudsakliga syftet med borrhålets placering var att ge ett ingenjörsgeologiskt underlag för projekteringen av slutförvarets nedfarter och centralområde. Den totala längden av KFM09B är 616,45 meter och den BIPS-bild som är användbar för kartering täcker intervallet 9,22–612,37 meter, efter längdjustering. Alla strukturer och litologier i det Boremapkarterade intervallet har dokumenterats i detalj genom att integrera information från borrkärnorna och BIPS-bilderna. De understa metrarna av borrhålet är dock karterade med Boremap utan kompletterande BIPS-bild.

KFM09B har borrats strax innanför den nordvästra begränsningen av kandidatområdet, längs de plastiska planstrukturerna i bergartsdomän 29. De flesta bergarters utsträckning och kontakter i denna domän är konkordanta med den tektoniska foliationen och de litologiska variationerna i KFM09B är därför relativt begränsade. Den dominerande bergarten i borrhålet är en medelkornig metagranit, av samma typ som den i övriga djupa kärnborrhål i undersökningsområdet. En annan viktig beståndsdel är pegmatitisk granit som utgör ungefär en fjärdedel av den karterade delen av borrhålet. En ansamling skarnlikt material, nära associerat med metagranit som i varierande grad genomgått albitisering, förekommer mellan 261 och 312 meters justerad längd. Andra bergartsenheter i KFM09B, av vilka inga överskrider ett fåtal meter i borrhålslängd, omfattar amfiboliter och fin- till medelkorniga metagranitoider av granitisk till granodioritisk sammansättning. Största delen av berggrunden i området har genomgått Svekofennisk amfibolitfacies-metamorfos. Ett intervall av porös, syenitisk bergart, som bildats genom selektiv kvartsupplösning, förekommer på 568,92–573,45 meter justerad längd.

Flertalet bergarter i KFM09B karaktäriseras av en sammansatt L-S struktur, med en dominans av tektonisk foliation. Totalt åtta mindre zoner med plastisk och spröd-plastisk deformation har registrerats i borrhålet. Flertalet skjuvzoner i KFM09B stupar brant och stryker ungefär åt SSO (dvs mer eller mindre parallellt med den lokala tektoniska foliationen).

Det totala antalet sprickor som registrerats och *inte ingår i krosszoner eller läkta spricknätverk* vid Boremapkarteringen av KFM09B, uppgår till 3 495. Av dessa är 677 öppna, 84 partiellt öppna och 2 734 läkta. Dessutom har 148 läkta spricknätverk, 19 breccior (eller breccierade intervall), tre krosszoner och två kataklasiter registrerats i det karterade intervallet. Den totala längden av de läkta spricknätverken uppgår till 22 meter (dvs 3,7% av det karterade intervallet). Klorit och kalcit är de överlägset vanligaste sprickmineralen i KFM09B. En typisk mineralassociation, som vanligtvis uppträder i sprickor som bedömts vara läkta, utgörs av laumontit tillsammans med kalcit och klorit, samt lokalt hematit, pyrit, kvarts och adularia. Andra mindre vanliga, men likväl karaktäristiska mineralassociationer, som huvudsakligen uppträder i läkta sprickor, är epidot + kalcit + klorit ± kvarts ± adularia och adularia + kalcit + klorit ± hematite ± kvarts. Mineral som till största delen är begränsade till öppna sprickor är lermineral och bergbeck. Pyrit och apofyllit är vanligt förekommande både i 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 data for the design of access tunnels and the central area of a final repository. To obtain such information, borehole KFM09B was drilled in the camp area, south of the Forsmark nuclear power plant, with 60° inclination towards SE (140°) (Figure 1-1). The borehole has a total length of about 616 metres.

The drilling activities in KFM09B were finished 19 December 2005, and the geological logging of the borehole started 5 February and ended 28 March 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 KFM09B, 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 400-05-130. 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 kärnborrhål KFM09B	AP PF 400-05-130	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
Instruktion: Regler för bergarters benämningar vid platsundersökningen i Forsmark	SKB MD 132.005	1.0

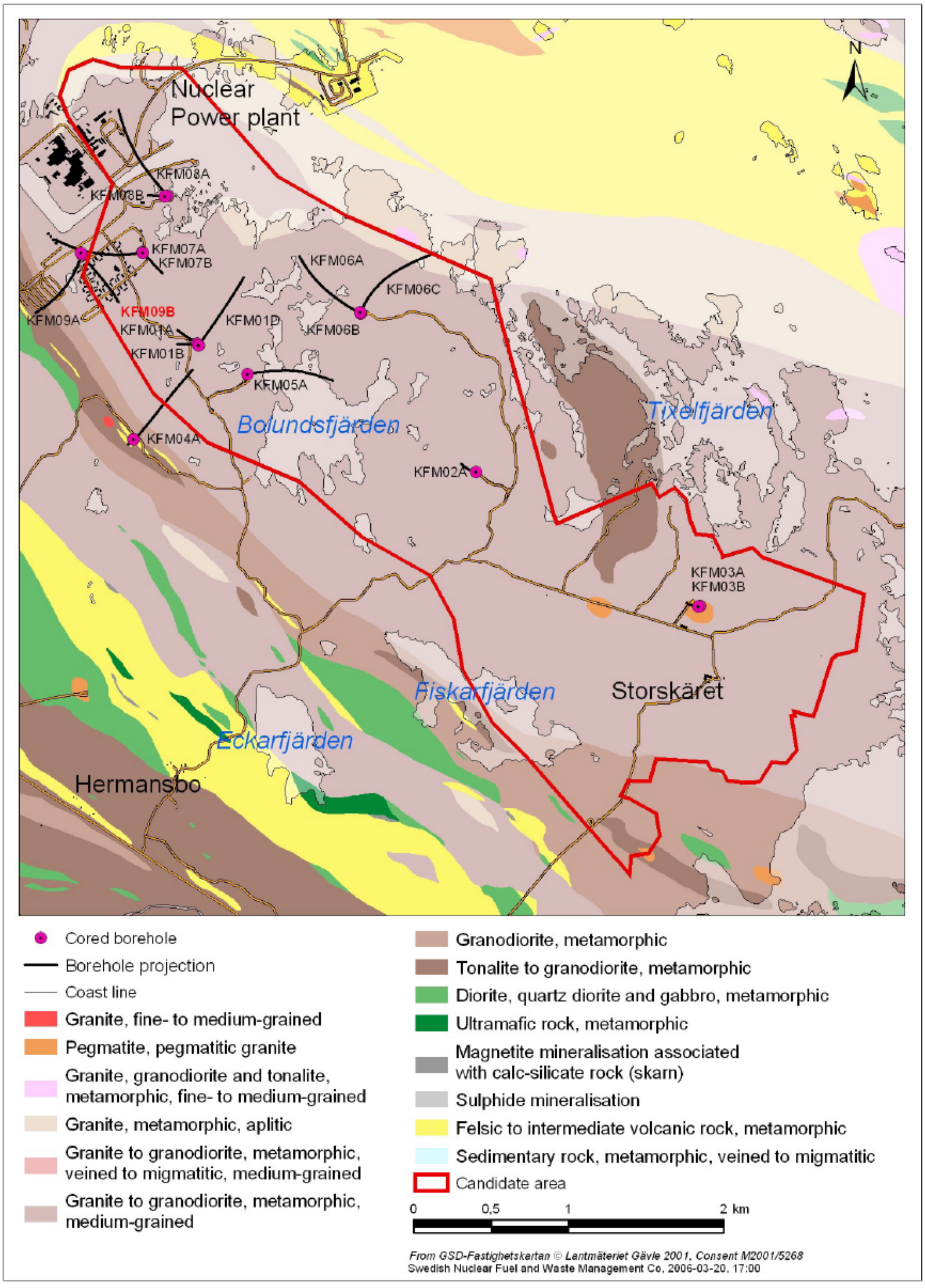

Figure 1-1. *Generalized geological map over Forsmark site investigation area and the projection of KFM09B in relation to other cored boreholes from the drilling programme.*

2 Objective and scope

The bedrock starts at 7.32 metres length in borehole KFM09B. The borehole is core drilled at Ø = 77.0 mm down to full its length at 616.45 metres. The diameter of the drill core is 51 mm under ideal conditions. The BIPS-image usable for geological logging covers the length interval 9.22–609.92 metres (after adjustment 9.22–612.37 metres). Thus, remaining part of the drill core, from 609.92 to 613.88 metres (after adjustment 613.88–616.33 metres), was mapped by Boremap without any complementary BIPS-image.

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 at Ø = 77.0 mm. 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. 3.75. 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 c. 600 metres drill core obtained from the interval 9.12–616.45 metres of KFM09B 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 KFM09B was followed 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 KFM09B was performed in Boremap v. 3.75 according to activity plan AP PF 400-05-130 (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). However, the generalised geophysical logs arrived after the geological mapping of the borehole was finished. The use of these logs was, therefore, limited to a few lithological ambiguities that remained after the mapping.

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

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 KFM09B is about 2.4 metres. It was, therefore, necessary to adjust the length in KFM09B with reference to groove millings cut into the borehole wall at every 50 metres, with the deepest slot at a length of 600 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 does never exceed 8 centimetres. 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 millimetre 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 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, occur consistently as extremely thin coatings or impurities in other fracture minerals, such as adularia and laumontite.

A drill induced crush has been registered at 535.50–535.55 of KFM9B.

4.5 Nonconformities

Several fractures within KFM09B 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 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 underrepresented in unbroken fractures.

As in previous cored boreholes, the mapping of KFM09B was locally hampered by deposited drill cuttings as well as brownish black coatings on the borehole. The most crucial quality-reducing factor in the uppermost part of the borehole is the drill cuttings. Minor fracture apertures might be difficult or even impossible to distinguish in these sections. The dark coating, on the other hand, occurs generally below c. 210 metres of KFM09B, where it typically forms a spiral pattern or a single band along the borehole axis. In the interval 370–416 metres, it locally obscures more than 80% of the borehole wall. Orientations registered for geological structures (e.g. fractures) in these intervals may, consequently, differ greatly from the actual orientations. This coating phenomenon is obviously drill induced, and the explanation proposed is that the coatings originate from metal fragments abraded from the drill rods.

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 KFM09B, though there might still be unnoticed errors. We disclaim the responsibility for all errors caused by the shortcomings in the software.

5 Results

5.1 Lithology

5.1.1 General

Borehole KFM09B is located just inside the north-western limit of the candidate area and plunges 60° southeast, along the ductile planar structures of rock domain 29 /cf SKB 2005/ in the area. Most rock extensions and contacts in this domain are concordant with the planar deformational fabric, and the lithological variations within KFM09B are, therefore, rather limited. The predominant rock type in KFM09B is a medium-grained metagranite (rock code 101057), which also prevails in the previously drilled deep boreholes located in the candidate area (i.e. rock domain 29). Another important component is pegmatitic granite (rock code 101061), which constitutes about one fourth of the mapped borehole interval.

A noteworthy feature in KFM09B is an occurrence of skarn-like material (rock code 108019) at 299.14–306.35 metres adjusted length. The low intersection angle between the borehole and the structural trend in this interval, suggests however that the orthogonal width of the occurrence is less than a metre. Other rock units in KFM09B, none of which forming occurrences that exceed a few metres in borehole length, include amphibolites (rock code 102017), fine- to medium-grained granite (rock code 111058) and fine- to medium-grained metagranitoid (rock code 101051) of granodioritic composition. 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 predominant 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 some intervals, especially in contact with amphibolites and skarn-like material, the rock is variably bleached and characterized by flecks of stretched biotite aggregates. Most of this variety is restricted to two major intervals at 258–319 and 444–481 metres. 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 ‘faint’ to ‘medium’.

Dykes, veins and segregations of pegmatite and pegmatitic granite are frequent throughout KFM09B. Most occurrences are some decimetre or less, but several pegmatites/pegmatitic granites exceed ten metres in borehole length. The most extensive occurrences of pegmatitic granite occur in the interval between 115 and 169 metres. 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 locally hematite, up to about one centimetre in diameter, has been identified in some pegmatites. Despite the textural variability and temporal span within this unit, most of these rocks were grouped as ‘pegmatite, pegmatitic granite’ (rock code 101061).

Amphibolites (rock code 102017) occur sporadically throughout KFM09B. Individual occurrences range up to 2.6 metres in borehole length. Generally, the amphibolites are 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 one decimetre wide rims of bleached wall rock, inferred to be the result of albitization. Disseminations of pyrite and/or other unidentifiable sulphides are macroscopically visible in some of the occurrences.

The occurrence of skarn-like material (rock code 108019) is generally concentrated into the interval between 261 and 312 metres, where it occurs in intimate association with metagranite that has been variably affected by albitization. Except for the occurrence at 299.14–306.35 metres adjusted length, as mentioned above, they are all less than 1.4 metres in borehole length. Contacts toward the surrounding albitized metagranite are typically vaguely defined or gradual. Individual occurrences are distinguished by their visible content of epidote and reddish feldspar or/and probable garnet. Other frequent components are quartz and magnetite.

Fine- to medium-grained metagranitoids (rock code 101051) of mostly granodioritic composition are scarce in KFM09B and limited to four separate occurrences. The two largest occur at 55.62–57.21 and 601.70–603.39 metres adjusted length. The rock is equigranular 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. Five occurrences of a fine- to medium-grained granite (rock code 111058), which locally is highly reminiscent of the fine-to medium-grained metagranitoid, are found in the borehole. A distinctive criterion apart from their late-tectonic character is, however, their anomalously high natural gamma radiation relative /cf Mattsson and Keisu 2006/. The most extensive occurrence occurs at 78.00–82.08 metres adjusted length. The other four occurrences are less than 5 decimetres in borehole-length.

Up to two decimetres wide occurrences of aplitic metagranite (rock code 101058) occur sporadically in the borehole. All of them show a distinct tectonic foliation. Quartz-dominated segregations or veins were coded as 8021. In addition, there are a few minor occurrences of granite, granodiorite, quartz diorite and “granitoid” in KFM09B. None of them appears to fit into the bedrock nomenclature defined by SKB MD 132.005. Instead they were coded as 1058 (unspecified granite), 1056 (unspecified granodiorite), 1038 (unspecified quartz diorite) and 1051 (unspecified granitoid). One minor occurrence of intermediate rock of inferred volcanic origin (rock code 103076) occurs at 514.29–514.33metres adjusted length.

5.2 Ductile structures

Most rocks in KFM09B are characterized by composite L-S fabrics, with a strong predominance of tectonic foliations. Some of the pegmatitic granites, the fine- to medium-grained metagranitoid (rock code 101051) and the fine to medium-grained granite (rock code 111058) are post-tectonic with respect to the main tectonic foliation, and are, therefore, massive or show a weak mineral lineation.

The intensity of the deformational fabric in KFM09B is mostly medium, and more rarely faint or weak. It must, however, be emphasized 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 pegmatites and some of the fine-grained mafic rocks. Most rocks have also undergone varying degrees of static recrystallization. The structural orientation in KFM09B is rather constant throughout the borehole and registered foliations are consistently steeply dipping and strike NNW–SSE to N–S (Figure 5-1). 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 eight narrow zones of more intense ductile and brittle-ductile deformation have been registered in KFM09B. Three of them are registered as mylonite, four as ductile shear zones and one as brittle-ductile shear zone. Mylonites are distinguished from the shear zones by the fact that the protolith is unidentifiable. The zones occur sporadically throughout KFM09B and the borehole length of individual zones is consistently less than two decimetres. The protolith in the zones seems mainly to be a highly deformed and grain-size reduced variety of the metagranite (rock code 101057), but also amphibolites (rock code 102017), quartz-dominated hydrothermal veins/segregations (rock code 8021) have been affected. Except for a SW striking mylonite at 118.2 metres adjusted length, all shear zones in KFM09B are steeply dipping and strikes roughly SSE (i.e. more or less parallel with the local tectonic foliation; Figure 5-1).

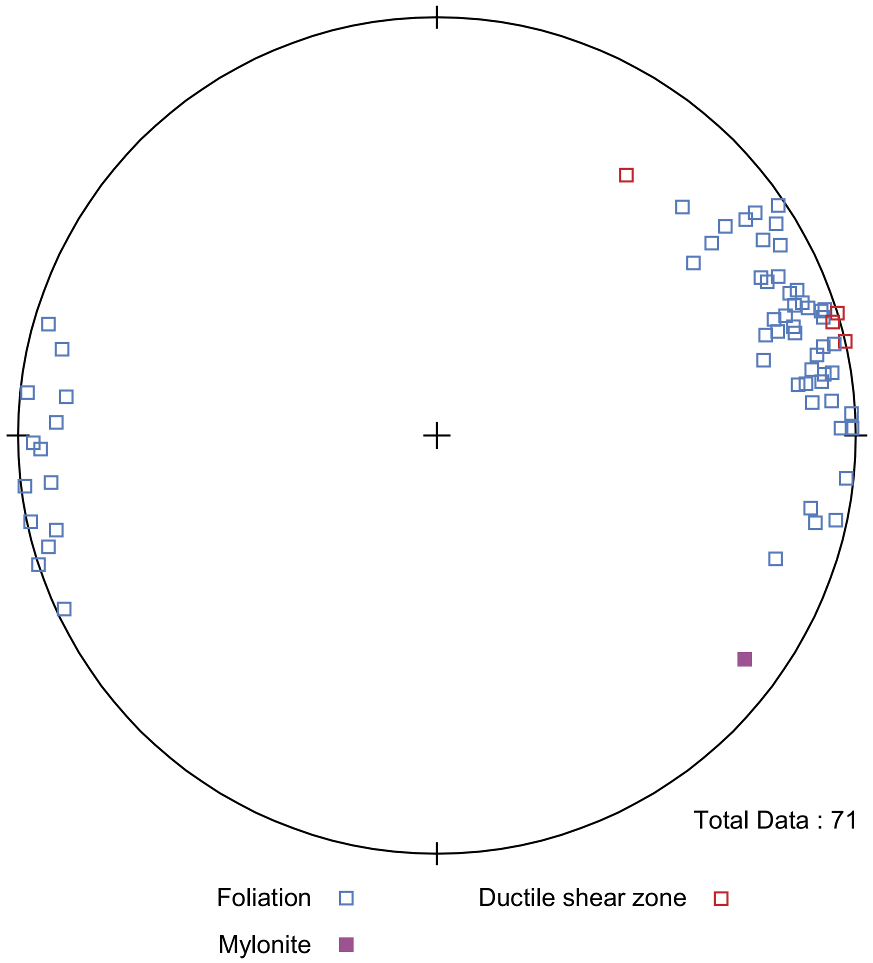

Figure 5-1. *Lower hemisphere, equal area stereographic projection showing poles to ductile structures in KFM09B.*

5.3 Alteration

Besides the albitization as discussed in Section 5.1, the most common alteration encountered in KFM09B is varying degrees of oxidation or red pigmentation of feldspars by sub-microscopic hematite. It is generally associated with more intensely fractured intervals, especially above 125 metres length and in the interval at 525–574 metres length. Totally, about 9% of the mapped interval of KFM09B has been affected by oxidation. Normally this oxidation is faint to weak in intensity, and more rarely medium.

Other types of alterations within KFM09B include laumontization, argillization, an occurrence of quartz dissolution and an alteration that gives the rock a slightly darker, blurred appearance (mapped as 'sassuritization' in Boremap). The presence of lamontization is restricted to four intervals with anomalously high frequency of laumontite sealed fractures. Clay dominated or argillic alteration is limited to two shorter intervals at 405.80–406.04 and 527.51–527.75 metres adjusted length. An interval of vuggy, syenitic rock at 568.92–573.45 metres adjusted length 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 has affected both the medium-grained metagranite (rock code 101057) and pegmatitic granite (rock code 101061). Individual vugs left after the dissolved quartz range up to a maximum of 18 millimetres in the pegmatitic section. Most vugs are, however, infilled by an assemblage dominated by quartz, clay minerals, and locally chlorite, epidote and hematite. An additional, centimetre-wide of vuggy, syenitic rock occurs at 382.31–382.32 metres adjusted length.

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 KFM09B amounts to 3,495, i.e. about 5.8 fractures/metres. Of these are 677 open, 84 partly open and 2,734 sealed. This separation in open, partly open or sealed fractures is made on the basis of the weathering of the fracture surface and fit of the fracture planes. It should be emphasized that there is a certain degree of uncertainty in these judgements.

In addition, there are 148 sealed networks, 19 breccias (or brecciated intervals) and two cataclasites 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 cataclasites. The latter should not be confused with 'cataclastic texture', here defined as a fine-scaled, heterogeneous fracture network controlled by grain boundaries and cleavage planes, which characterize a few pegmatitic granites in the length interval at 529–543 metres. 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 KFM09B amount to 22 metres (i.e. 3.7% 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 4 cm. This makes about 1,700 additional sealed fractures in the mapped interval of the borehole.

Breccias are found throughout the borehole, with a major concentration between 528 and 547 metres length. Individual occurrences range up to 0.5 metre in width, though the majority of them is less than one decimetre wide. Except for the registered zones of breccia and cataclasite, there are seven fractures with measurable displacements registered in KFM09B. Most of them occur in the length interval 31–67 metres.

Totally three crush zones occur in KFM09B. Two of them are three decimetres wide and occur in the length interval 19.3–20.3 metres adjusted length, whereas the third is 2.6 centimetres wide and occurs at 310.74–310.77 metres length. The uppermost zone is gently dipping, whereas the two other are sub-vertical.

Throughout the borehole, the frequency of open and sealed fractures varies rather coherently, with an increased number of open fractures in intervals with concentrations of sealed fractures (Appendix 1). There are several intervals with anomalously high fracture frequencies throughout the borehole, though few of them are especially well-defined, and all are dominated by sealed fractures, many included in sealed fracture networks. Generally, there are three major intervals with increased fracture frequency relative to the remaining part of the borehole. The most well-defined interval occurs at 520–574. The other two occur at 9–153 and 280–410 metres length. However, the fracture frequency is highly variable within each of these intervals.

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 24% of the contacts in the mapped interval of KFM09B 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/.

No core discing has been registered in KFM09B.

5.4.2 Fracture mineralogy

Chlorite and/or calcite are found in about 80% of the total number of the registered fractures in KFM09B. Other infilling minerals, in order of decreasing abundance, include laumontite, sub-microscopic hematite, pyrite, adularia, clay minerals, quartz, prehnite, epidote, white feldspar, biotite, asphaltite, apophyllite and more rarely, sericite, molybdenite, iron hydroxide, amphibole, pyrrhotite, unspecified sulphides and unspecified zeolites. In addition, there are two 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 116 fractures that are virtually free from visible mineral coatings. Approximately half 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. Clay minerals registered in fractures at greater depths are typically corrensite and illite, often intimately associated with chlorite. Other minerals preferably found in open and partly open fractures are asphaltite, sericite, molybdenite (mapped as X2) and iron hydroxide. Both the asphaltite and iron hydroxide are restricted to rather short intervals above 67 and 42 metres length, respectively.

Pyrite is frequent in both sealed and open fractures. The presence of other sulphides, including pyrrhotite and ‘unspecified sulphides’, are rare and restricted to four fractures. Also the findings of apophyllite (mapped as X1) is spread rather equally between open or sealed fractures.

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 calcite, chlorite, and locally hematite, pyrite, quartz and adularia. However, the exact assemblage varies locally. A number of very thin (<< 1 mm), 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. This interpretation is based on the fact the hematite within KFM09B typically 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.

Other, less common, but yet characteristic assemblages, mainly found in the sealed fractures is epidote + calcite + chlorite ± quartz ± adularia and adularia + calcite + chlorite ± hematite ± quartz ± adularia. The majority of the epidote-dominated fractures is restricted to a rather narrow length interval at 540–546 metres. The adularia-dominated fractures, on the other hand, mostly occur in the length interval 280–360 metres. Prehnite are with few exceptions limited to thin, sealed fractures found within amphibolites and related rocks. Subsequent EDS-analysis of some of these fractures has revealed that most of the light greenish minerals inferred to be prehnite in fact are epidote (B. Sandström, written commumication).

White feldspar is mainly registered in fractures below 360 metres length. The term is used for white or colourless adularia as well as suspected albite. Biotite and hornblende/amphibole are found in fractures inferred to be late-, rather than post-metamorphic in the length interval 262–309 metres. These fractures are typically mono-mineralic or include minor amounts of pyrite and/or prehnite.

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Appendix 1

WellCAD image

Title	LEGEND FOR FORSMARK	KFM09B	Appendix: 1

Site: FORSMARK
Borehole: KFM09B
Plot Date: 2006-05-28 21:14:54
Signed data

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

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

MINERAL
- Epidote
- White Feldspar
- Hematite
- Calcite
- Chlorite
- Quartz
- Pyrite
- Clay Minerals
- Laumontite
- Prehnite
- Asphalt
- Oxidized Walls

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

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

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

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

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

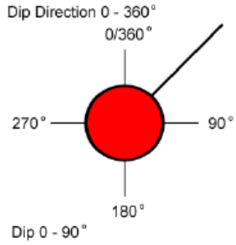
ROUGHNESS
- Planar
- Undulating
- Stepped
- Irregular

SURFACE
- Rough
- Smooth
- Slickensided

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

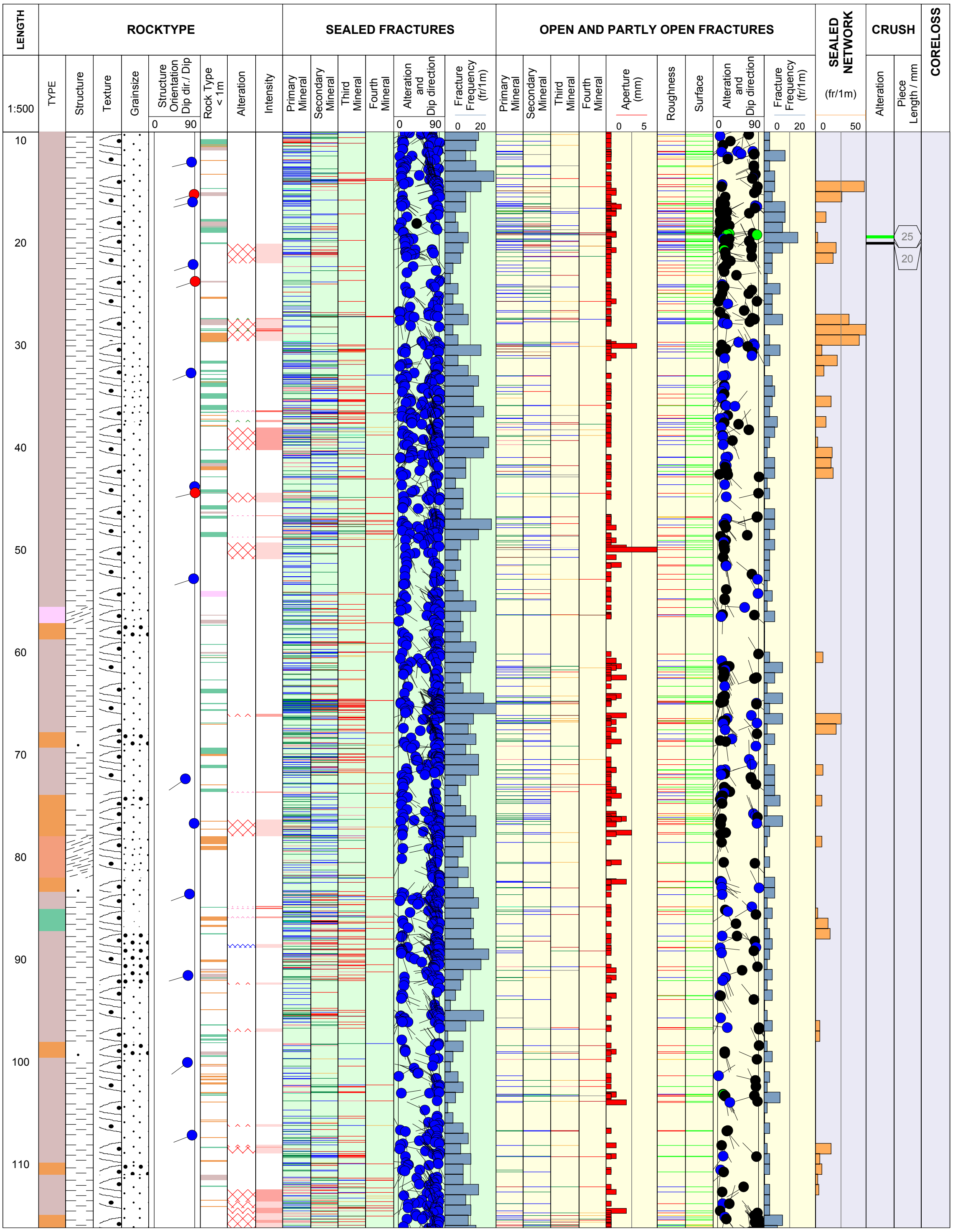
FRACTURE ALTERATION
- Slightly Altered
- Moderately Altered
- Highly Altered
- Completely Altered
- Gouge
- Fresh

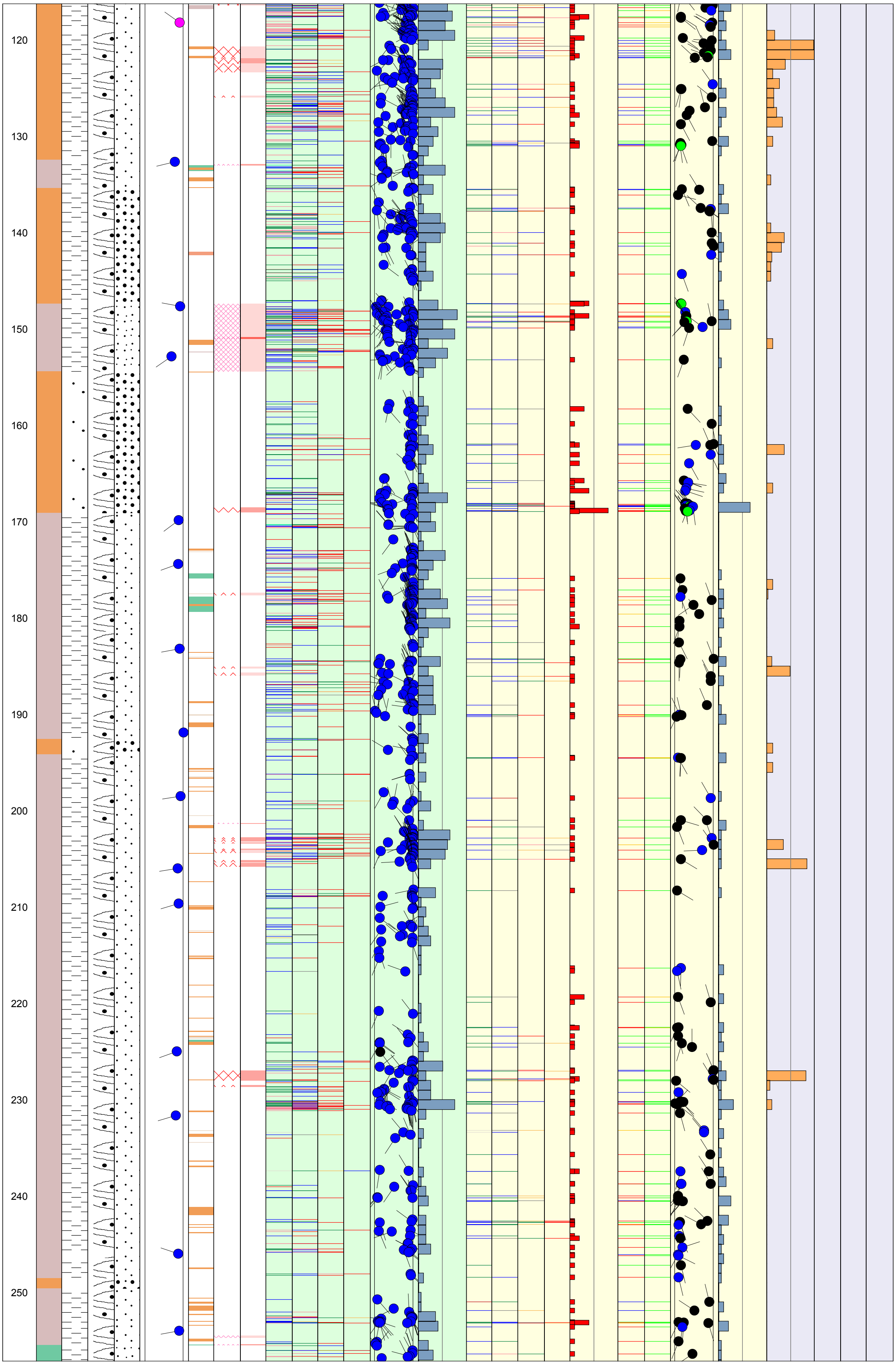
FRACTURE DIRECTION
STRUKTURE ORIENTATION



Title GEOLOGY IN KFM09B **Appendix: 1**

Site	FORSMARK	**Coordinate System**	RT90-RHB70
Borehole	KFM09B	**Northing [m]**	6700119.89
Diameter [mm]	77	**Easting [m]**	1630638.78
Length [m]	616.450	**Elevation [m.a.s.l.]**	4.30
Bearing [°]	140.83	**Drilling Start Date**	2005-11-15 00:00:00
Inclination [°]	-55.07	**Drilling Stop Date**	2005-11-15 00:00:00
Date of coremapping	2006-02-05 10:35:00	**Plot Date**	2006-05-28 21:14:54
Rocktype data from	p_rock	**Signed data**	





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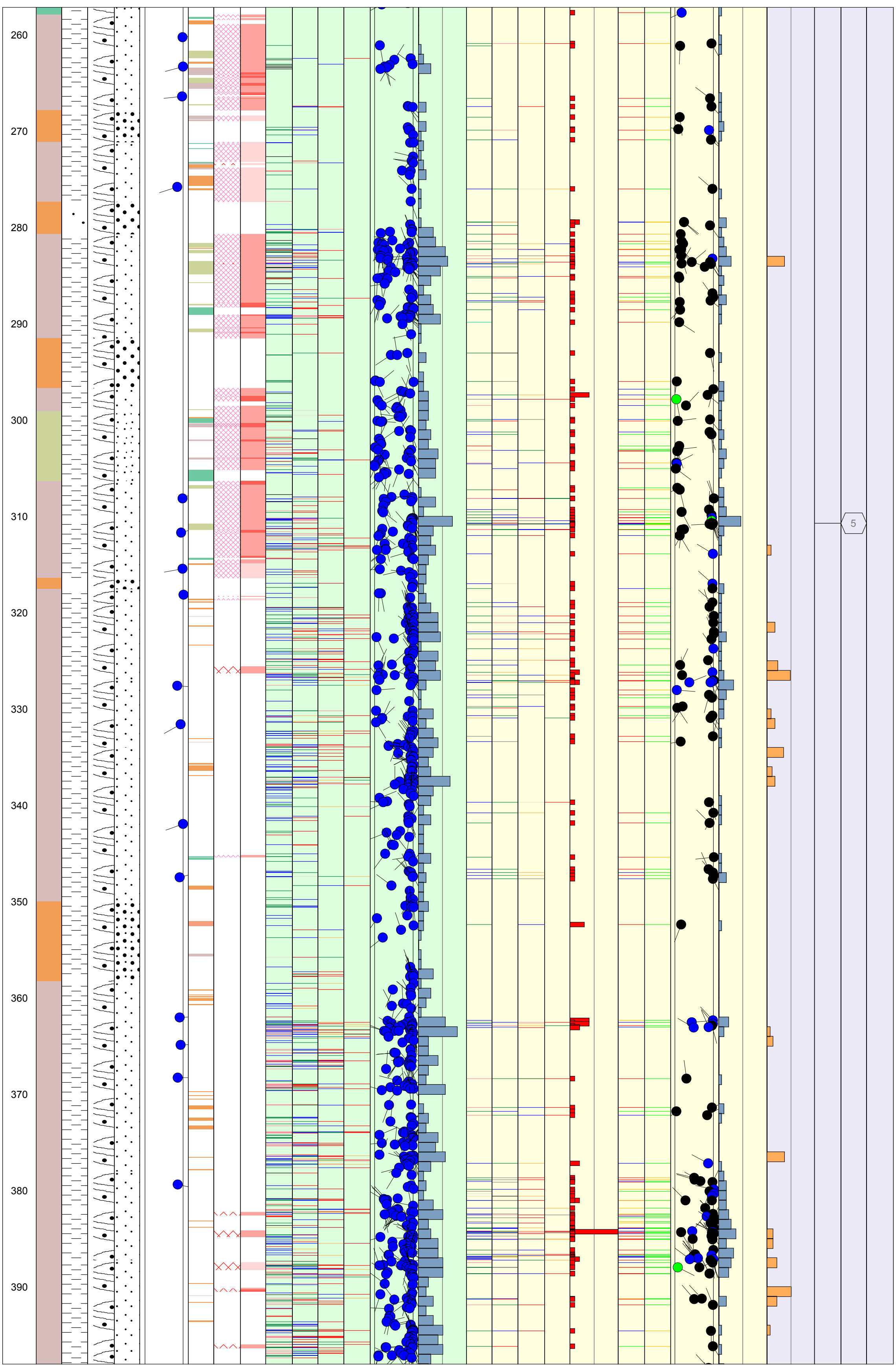
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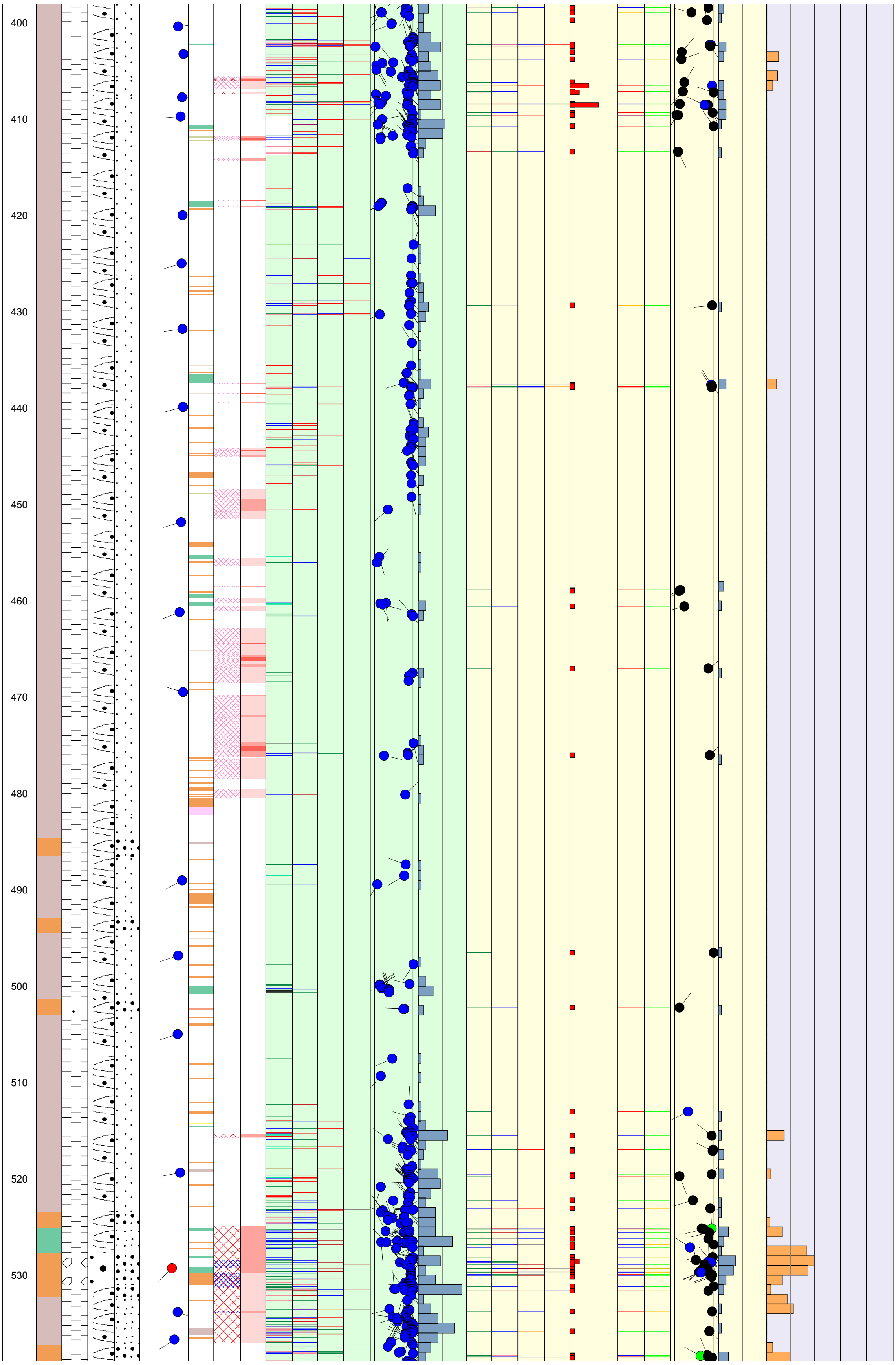
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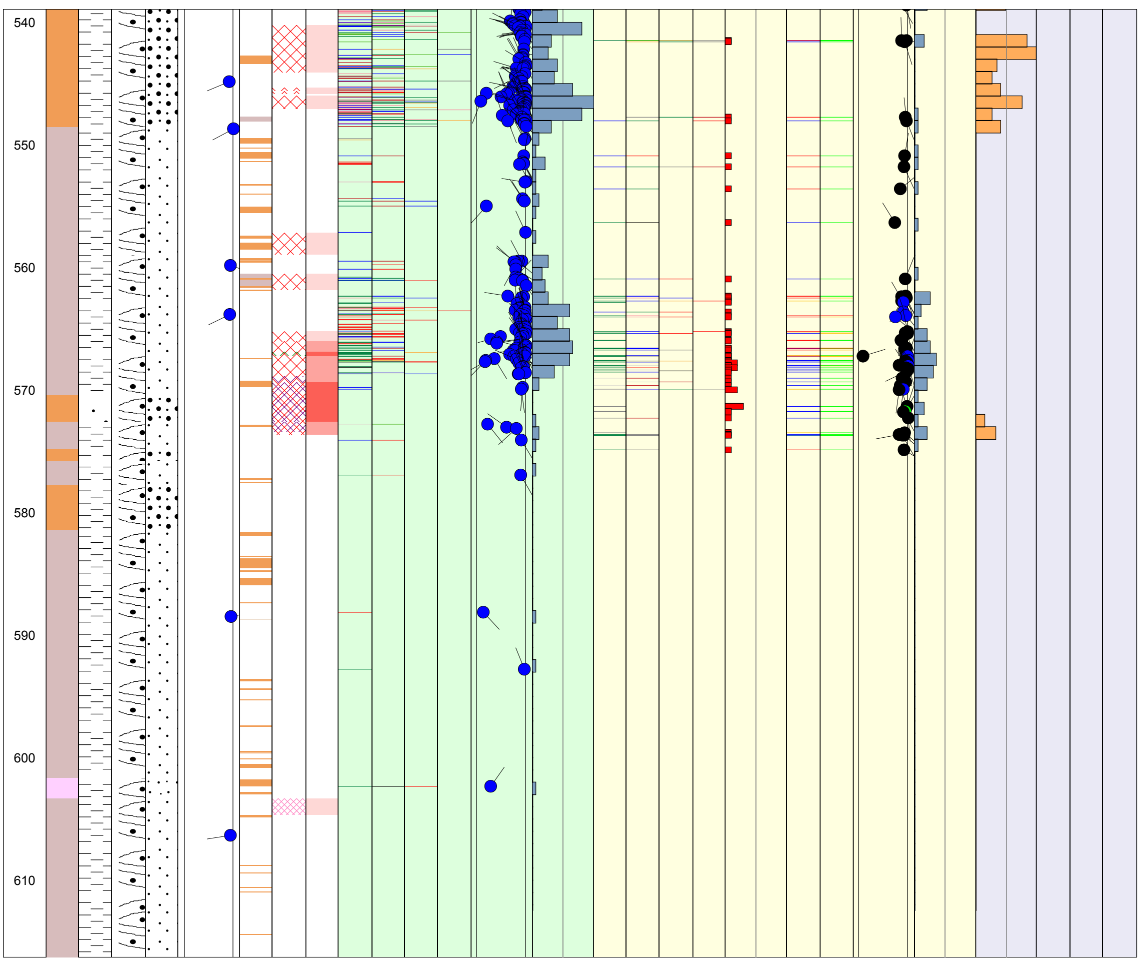

540
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570
580
590
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610

Appendix 2

Borehole diameters

Hole Diam T – Drilling: Borehole diameter

KFM09B, 2005-11-16 00:00:00 – 2005-12-19 00:00:00 (9.120–616.450 m).

Sub secup (m)	Sub seclow (m)	Hole diam (m)	Comment
9.120	616.450	0.0770	

Printout from SICADA 2006-04-18 12:48:04.

Appendix 3

Downhole deviation measurements

Maxibor T – Borehole deviation: Maxibor

KFM09B, 2005-12-21 03:30:00 – 2005-12-21 07:00:00 (3.000–612.000 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	6700119.89	1630638.78	–4.30	RT90-RHB70	–55.08	140.83	0.0000	0.0000	0.0000	
3.00	6700118.56	1630639.88	–1.84	RT90-RHB70	–55.08	140.83	0.0000	0.0000	0.0000	
6.00	6700117.22	1630640.96	0.62	RT90-RHB70	–55.02	140.86	1.7200	0.0000	0.0000	
9.00	6700115.89	1630642.05	3.07	RT90-RHB70	–54.97	140.76	3.4400	0.0000	0.0000	
12.00	6700114.56	1630643.14	5.53	RT90-RHB70	–54.91	140.67	5.1600	0.0000	0.0100	
15.00	6700113.22	1630644.23	7.99	RT90-RHB70	–54.84	140.62	6.8800	–0.0100	0.0200	
18.00	6700111.89	1630645.33	10.44	RT90-RHB70	–54.85	140.57	8.6100	–0.0100	0.0300	
21.00	6700110.55	1630646.42	12.89	RT90-RHB70	–54.85	140.56	10.3400	–0.0200	0.0400	
24.00	6700109.22	1630647.52	15.34	RT90-RHB70	–54.83	140.58	12.0700	–0.0300	0.0600	
27.00	6700107.88	1630648.62	17.80	RT90-RHB70	–54.82	140.63	13.7900	–0.0400	0.0700	
30.00	6700106.55	1630649.72	20.25	RT90-RHB70	–54.81	140.65	15.5200	–0.0400	0.0800	
33.00	6700105.21	1630650.81	22.70	RT90-RHB70	–54.81	140.71	17.2500	–0.0500	0.1000	
36.00	6700103.87	1630651.91	25.15	RT90-RHB70	–54.78	140.76	18.9800	–0.0500	0.1100	
39.00	6700102.53	1630653.00	27.60	RT90-RHB70	–54.74	140.77	20.7100	–0.0500	0.1300	
42.00	6700101.19	1630654.10	30.05	RT90-RHB70	–54.69	140.77	22.4400	–0.0600	0.1400	
45.00	6700099.85	1630655.19	32.50	RT90-RHB70	–54.65	140.76	24.1800	–0.0600	0.1600	
48.00	6700098.50	1630656.29	34.95	RT90-RHB70	–54.62	140.75	25.9100	–0.0600	0.1900	
51.00	6700097.16	1630657.39	37.39	RT90-RHB70	–54.59	140.77	27.6500	–0.0600	0.2100	
54.00	6700095.81	1630658.49	39.84	RT90-RHB70	–54.58	140.77	29.3900	–0.0700	0.2400	
57.00	6700094.47	1630659.59	42.28	RT90-RHB70	–54.55	140.79	31.1300	–0.0700	0.2600	
60.00	6700093.12	1630660.69	44.73	RT90-RHB70	–54.52	140.81	32.8700	–0.0700	0.2900	
63.00	6700091.77	1630661.79	47.17	RT90-RHB70	–54.49	140.79	34.6100	–0.0700	0.3200	
66.00	6700090.42	1630662.89	49.61	RT90-RHB70	–54.45	140.73	36.3500	–0.0700	0.3500	
69.00	6700089.07	1630663.99	52.05	RT90-RHB70	–54.40	140.69	38.0900	–0.0700	0.3800	

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
72.00	6700087.72	1630665.10	54.49	RT90-RHB70	–54.36	140.70	39.8400	–0.0800	0.4200	
75.00	6700086.36	1630666.21	56.93	RT90-RHB70	–54.31	140.69	41.5900	–0.0800	0.4600	
78.00	6700085.01	1630667.32	59.37	RT90-RHB70	–54.26	140.67	43.3400	–0.0900	0.5000	
81.00	6700083.65	1630668.43	61.80	RT90-RHB70	–54.20	140.65	45.0900	–0.0900	0.5400	
84.00	6700082.30	1630669.54	64.24	RT90-RHB70	–54.16	140.59	46.8500	–0.1000	0.5900	
87.00	6700080.94	1630670.66	66.67	RT90-RHB70	–54.12	140.60	48.6000	–0.1000	0.6400	
90.00	6700079.58	1630671.77	69.10	RT90-RHB70	–54.08	140.59	50.3600	–0.1100	0.6900	
93.00	6700078.22	1630672.89	71.53	RT90-RHB70	–54.03	140.63	52.1200	–0.1200	0.7400	
96.00	6700076.86	1630674.01	73.96	RT90-RHB70	–53.97	140.67	53.8800	–0.1300	0.7900	
99.00	6700075.49	1630675.13	76.38	RT90-RHB70	–53.92	140.67	55.6500	–0.1300	0.8500	
102.00	6700074.13	1630676.24	78.81	RT90-RHB70	–53.86	140.67	57.4100	–0.1400	0.9100	
105.00	6700072.76	1630677.37	81.23	RT90-RHB70	–53.81	140.68	59.1800	–0.1400	0.9800	
108.00	6700071.39	1630678.49	83.65	RT90-RHB70	–53.78	140.68	60.9500	–0.1500	1.0400	
111.00	6700070.02	1630679.61	86.07	RT90-RHB70	–53.74	140.67	62.7300	–0.1500	1.1100	
114.00	6700068.65	1630680.74	88.49	RT90-RHB70	–53.71	140.68	64.5000	–0.1600	1.1800	
117.00	6700067.27	1630681.86	90.91	RT90-RHB70	–53.68	140.66	66.2800	–0.1600	1.2500	
120.00	6700065.90	1630682.99	93.32	RT90-RHB70	–53.64	140.65	68.0500	–0.1700	1.3300	
123.00	6700064.52	1630684.12	95.74	RT90-RHB70	–53.59	140.64	69.8300	–0.1700	1.4000	
126.00	6700063.15	1630685.24	98.15	RT90-RHB70	–53.56	140.61	71.6100	–0.1800	1.4800	
129.00	6700061.77	1630686.38	100.57	RT90-RHB70	–53.53	140.58	73.4000	–0.1800	1.5600	
132.00	6700060.39	1630687.51	102.98	RT90-RHB70	–53.51	140.54	75.1800	–0.1900	1.6400	
135.00	6700059.01	1630688.64	105.39	RT90-RHB70	–53.48	140.52	76.9600	–0.2000	1.7200	
138.00	6700057.64	1630689.78	107.80	RT90-RHB70	–53.45	140.49	78.7500	–0.2100	1.8100	
141.00	6700056.26	1630690.91	110.21	RT90-RHB70	–53.40	140.48	80.5300	–0.2200	1.8900	
144.00	6700054.88	1630692.05	112.62	RT90-RHB70	–53.34	140.47	82.3200	–0.2300	1.9800	
147.00	6700053.50	1630693.19	115.03	RT90-RHB70	–53.26	140.43	84.1100	–0.2400	2.0700	
150.00	6700052.11	1630694.33	117.43	RT90-RHB70	–53.18	140.43	85.9100	–0.2600	2.1700	
153.00	6700050.73	1630695.48	119.83	RT90-RHB70	–53.09	140.42	87.7100	–0.2700	2.2700	
156.00	6700049.34	1630696.63	122.23	RT90-RHB70	–53.00	140.43	89.5100	–0.2800	2.3700	
159.00	6700047.95	1630697.78	124.63	RT90-RHB70	–52.94	140.41	91.3100	–0.3000	2.4800	

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
162.00	6700046.55	1630698.93	127.02	RT90-RHB70	–52.85	140.36	93.1200	–0.3100	2.5900	
165.00	6700045.16	1630700.09	129.41	RT90-RHB70	–52.77	140.33	94.9300	–0.3200	2.7100	
168.00	6700043.76	1630701.24	131.80	RT90-RHB70	–52.68	140.32	96.7500	–0.3400	2.8300	
171.00	6700042.36	1630702.41	134.19	RT90-RHB70	–52.62	140.31	98.5700	–0.3600	2.9500	
174.00	6700040.96	1630703.57	136.57	RT90-RHB70	–52.58	140.28	100.3900	–0.3700	3.0800	
177.00	6700039.56	1630704.73	138.96	RT90-RHB70	–52.55	140.21	102.2100	–0.3900	3.2100	
180.00	6700038.16	1630705.90	141.34	RT90-RHB70	–52.54	140.16	104.0300	–0.4100	3.3500	
183.00	6700036.75	1630707.07	143.72	RT90-RHB70	–52.53	140.12	105.8600	–0.4300	3.4800	
186.00	6700035.35	1630708.24	146.10	RT90-RHB70	–52.50	140.12	107.6800	–0.4500	3.6100	
189.00	6700033.95	1630709.41	148.48	RT90-RHB70	–52.45	140.09	109.5100	–0.4800	3.7500	
192.00	6700032.55	1630710.58	150.86	RT90-RHB70	–52.41	140.07	111.3400	–0.5000	3.8800	
195.00	6700031.15	1630711.76	153.24	RT90-RHB70	–52.37	140.03	113.1700	–0.5300	4.0200	
198.00	6700029.74	1630712.94	155.61	RT90-RHB70	–52.34	140.01	115.0000	–0.5500	4.1700	
201.00	6700028.34	1630714.11	157.99	RT90-RHB70	–52.31	139.96	116.8300	–0.5800	4.3100	
204.00	6700026.93	1630715.29	160.36	RT90-RHB70	–52.27	139.92	118.6700	–0.6100	4.4500	
207.00	6700025.53	1630716.48	162.73	RT90-RHB70	–52.21	139.89	120.5000	–0.6300	4.6000	
210.00	6700024.12	1630717.66	165.10	RT90-RHB70	–52.15	139.89	122.3400	–0.6700	4.7500	
213.00	6700022.72	1630718.85	167.47	RT90-RHB70	–52.11	139.83	124.1800	–0.7000	4.9000	
216.00	6700021.31	1630720.03	169.84	RT90-RHB70	–52.06	139.80	126.0200	–0.7300	5.0600	
219.00	6700019.90	1630721.23	172.21	RT90-RHB70	–52.01	139.77	127.8700	–0.7600	5.2200	
222.00	6700018.49	1630722.42	174.57	RT90-RHB70	–51.95	139.77	129.7100	–0.8000	5.3800	
225.00	6700017.08	1630723.61	176.93	RT90-RHB70	–51.91	139.74	131.5600	–0.8300	5.5400	
228.00	6700015.67	1630724.81	179.29	RT90-RHB70	–51.86	139.73	133.4100	–0.8600	5.7100	
231.00	6700014.25	1630726.01	181.65	RT90-RHB70	–51.79	139.73	135.2600	–0.9000	5.8800	
234.00	6700012.84	1630727.20	184.01	RT90-RHB70	–51.75	139.71	137.1200	–0.9400	6.0500	
237.00	6700011.42	1630728.41	186.37	RT90-RHB70	–51.70	139.70	138.9800	–0.9700	6.2200	
240.00	6700010.00	1630729.61	188.72	RT90-RHB70	–51.65	139.66	140.8400	–1.0100	6.4000	
243.00	6700008.58	1630730.81	191.07	RT90-RHB70	–51.59	139.64	142.7000	–1.0500	6.5800	
246.00	6700007.16	1630732.02	193.42	RT90-RHB70	–51.51	139.59	144.5600	–1.0900	6.7600	
249.00	6700005.74	1630733.23	195.77	RT90-RHB70	–51.44	139.59	146.4300	–1.1300	6.9500	

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
252.00	6700004.32	1630734.44	198.12	RT90-RHB70	–51.37	139.58	148.3000	–1.1700	7.1400	
255.00	6700002.89	1630735.66	200.46	RT90-RHB70	–51.33	139.56	150.1700	–1.2100	7.3300	
258.00	6700001.46	1630736.87	202.80	RT90-RHB70	–51.30	139.56	152.0400	–1.2500	7.5300	
261.00	6700000.04	1630738.09	205.15	RT90-RHB70	–51.26	139.57	153.9200	–1.2900	7.7200	
264.00	6699998.61	1630739.31	207.49	RT90-RHB70	–51.26	139.56	155.7900	–1.3300	7.9200	
267.00	6699997.18	1630740.52	209.83	RT90-RHB70	–51.26	139.53	157.6700	–1.3700	8.1200	
270.00	6699995.75	1630741.74	212.17	RT90-RHB70	–51.27	139.53	159.5500	–1.4200	8.3200	
273.00	6699994.32	1630742.96	214.51	RT90-RHB70	–51.27	139.51	161.4200	–1.4600	8.5200	
276.00	6699992.89	1630744.18	216.85	RT90-RHB70	–51.23	139.50	163.3000	–1.5000	8.7200	
279.00	6699991.47	1630745.40	219.19	RT90-RHB70	–51.20	139.49	165.1800	–1.5500	8.9200	
282.00	6699990.04	1630746.62	221.52	RT90-RHB70	–51.16	139.47	167.0600	–1.5900	9.1200	
285.00	6699988.61	1630747.84	223.86	RT90-RHB70	–51.11	139.44	168.9400	–1.6400	9.3300	
288.00	6699987.18	1630749.07	226.20	RT90-RHB70	–51.05	139.39	170.8200	–1.6800	9.5400	
291.00	6699985.74	1630750.30	228.53	RT90-RHB70	–50.99	139.41	172.7100	–1.7300	9.7500	
294.00	6699984.31	1630751.53	230.86	RT90-RHB70	–50.93	139.41	174.6000	–1.7800	9.9600	
297.00	6699982.87	1630752.76	233.19	RT90-RHB70	–50.88	139.44	176.4900	–1.8200	10.1800	
300.00	6699981.44	1630753.99	235.52	RT90-RHB70	–50.85	139.43	178.3800	–1.8700	10.4000	
303.00	6699980.00	1630755.22	237.84	RT90-RHB70	–50.83	139.43	180.2700	–1.9200	10.6200	
306.00	6699978.56	1630756.45	240.17	RT90-RHB70	–50.80	139.45	182.1700	–1.9600	10.8400	
309.00	6699977.12	1630757.68	242.49	RT90-RHB70	–50.75	139.54	184.0600	–2.0100	11.0600	
312.00	6699975.67	1630758.91	244.82	RT90-RHB70	–50.71	139.61	185.9600	–2.0500	11.2900	
315.00	6699974.23	1630760.15	247.14	RT90-RHB70	–50.64	139.66	187.8600	–2.0900	11.5200	
318.00	6699972.78	1630761.38	249.46	RT90-RHB70	–50.57	139.70	189.7600	–2.1300	11.7500	
321.00	6699971.32	1630762.61	251.77	RT90-RHB70	–50.49	139.67	191.6700	–2.1700	11.9900	
324.00	6699969.87	1630763.85	254.09	RT90-RHB70	–50.44	139.72	193.5800	–2.2100	12.2200	
327.00	6699968.41	1630765.08	256.40	RT90-RHB70	–50.38	139.72	195.4900	–2.2400	12.4700	
330.00	6699966.95	1630766.32	258.71	RT90-RHB70	–50.31	139.72	197.4000	–2.2800	12.7100	
333.00	6699965.49	1630767.56	261.02	RT90-RHB70	–50.25	139.70	199.3100	–2.3200	12.9600	
336.00	6699964.03	1630768.80	263.33	RT90-RHB70	–50.17	139.67	201.2300	–2.3600	13.2100	
339.00	6699962.56	1630770.04	265.63	RT90-RHB70	–50.11	139.67	203.1500	–2.3900	13.4700	

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
342.00	6699961.09	1630771.29	267.93	RT90-RHB70	–50.06	139.66	205.0800	–2.4300	13.7300	
345.00	6699959.63	1630772.53	270.23	RT90-RHB70	–50.01	139.68	207.0000	–2.4700	13.9900	
348.00	6699958.16	1630773.78	272.53	RT90-RHB70	–49.93	139.69	208.9300	–2.5100	14.2600	
351.00	6699956.68	1630775.03	274.83	RT90-RHB70	–49.84	139.72	210.8600	–2.5500	14.5300	
354.00	6699955.21	1630776.28	277.12	RT90-RHB70	–49.74	139.74	212.7900	–2.5900	14.8000	
357.00	6699953.73	1630777.53	279.41	RT90-RHB70	–49.66	139.73	214.7300	–2.6300	15.0800	
360.00	6699952.25	1630778.79	281.70	RT90-RHB70	–49.58	139.73	216.6700	–2.6600	15.3600	
363.00	6699950.76	1630780.05	283.98	RT90-RHB70	–49.52	139.73	218.6200	–2.7000	15.6500	
366.00	6699949.28	1630781.30	286.26	RT90-RHB70	–49.46	139.86	220.5700	–2.7400	15.9400	
369.00	6699947.79	1630782.56	288.54	RT90-RHB70	–49.40	140.01	222.5200	–2.7700	16.2300	
372.00	6699946.29	1630783.82	290.82	RT90-RHB70	–49.33	140.17	224.4700	–2.8000	16.5300	
375.00	6699944.79	1630785.07	293.10	RT90-RHB70	–49.23	140.24	226.4200	–2.8200	16.8300	
378.00	6699943.28	1630786.32	295.37	RT90-RHB70	–49.11	140.35	228.3800	–2.8400	17.1400	
381.00	6699941.77	1630787.57	297.64	RT90-RHB70	–49.01	140.48	230.3500	–2.8600	17.4500	
384.00	6699940.25	1630788.83	299.90	RT90-RHB70	–48.92	140.63	232.3100	–2.8700	17.7700	
387.00	6699938.73	1630790.08	302.16	RT90-RHB70	–48.78	140.79	234.2800	–2.8800	18.0900	
390.00	6699937.20	1630791.33	304.42	RT90-RHB70	–48.68	140.88	236.2600	–2.8800	18.4200	
393.00	6699935.66	1630792.58	306.67	RT90-RHB70	–48.58	140.98	238.2400	–2.8800	18.7500	
396.00	6699934.12	1630793.83	308.92	RT90-RHB70	–48.47	141.12	240.2300	–2.8700	19.0900	
399.00	6699932.57	1630795.07	311.17	RT90-RHB70	–48.39	141.20	242.2200	–2.8600	19.4400	
402.00	6699931.02	1630796.32	313.41	RT90-RHB70	–48.34	141.27	244.2100	–2.8500	19.7900	
405.00	6699929.46	1630797.57	315.65	RT90-RHB70	–48.30	141.33	246.2000	–2.8300	20.1400	
408.00	6699927.90	1630798.82	317.89	RT90-RHB70	–48.25	141.49	248.2000	–2.8200	20.4900	
411.00	6699926.34	1630800.06	320.13	RT90-RHB70	–48.22	141.65	250.2000	–2.7900	20.8500	
414.00	6699924.77	1630801.30	322.37	RT90-RHB70	–48.13	141.77	252.1900	–2.7700	21.2100	
417.00	6699923.20	1630802.54	324.60	RT90-RHB70	–48.06	141.92	254.2000	–2.7300	21.5700	
420.00	6699921.62	1630803.78	326.83	RT90-RHB70	–47.96	142.07	256.2000	–2.7000	21.9400	
423.00	6699920.04	1630805.01	329.06	RT90-RHB70	–47.89	142.22	258.2100	–2.6500	22.3100	
426.00	6699918.45	1630806.24	331.29	RT90-RHB70	–47.80	142.35	260.2200	–2.6000	22.6800	
429.00	6699916.85	1630807.48	333.51	RT90-RHB70	–47.72	142.52	262.2300	–2.5500	23.0600	

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
432.00	6699915.25	1630808.70	335.73	RT90-RHB70	–47.64	142.67	264.2500	–2.4900	23.4500	
435.00	6699913.64	1630809.93	337.94	RT90-RHB70	–47.58	142.83	266.2700	–2.4300	23.8300	
438.00	6699912.03	1630811.15	340.16	RT90-RHB70	–47.52	143.01	268.2900	–2.3600	24.2200	
441.00	6699910.41	1630812.37	342.37	RT90-RHB70	–47.44	143.16	270.3200	–2.2800	24.6200	
444.00	6699908.79	1630813.59	344.58	RT90-RHB70	–47.32	143.27	272.3500	–2.2000	25.0100	
447.00	6699907.16	1630814.80	346.79	RT90-RHB70	–47.21	143.37	274.3800	–2.1100	25.4200	
450.00	6699905.52	1630816.02	348.99	RT90-RHB70	–47.13	143.57	276.4100	–2.0200	25.8300	
453.00	6699903.88	1630817.23	351.19	RT90-RHB70	–47.06	143.76	278.4500	–1.9200	26.2400	
456.00	6699902.23	1630818.44	353.38	RT90-RHB70	–46.99	143.93	280.4900	–1.8200	26.6600	
459.00	6699900.58	1630819.64	355.58	RT90-RHB70	–46.93	144.11	282.5400	–1.7100	27.0800	
462.00	6699898.92	1630820.85	357.77	RT90-RHB70	–46.86	144.27	284.5800	–1.5900	27.5000	
465.00	6699897.25	1630822.04	359.96	RT90-RHB70	–46.77	144.42	286.6300	–1.4700	27.9300	
468.00	6699895.58	1630823.24	362.14	RT90-RHB70	–46.65	144.51	288.6800	–1.3400	28.3600	
471.00	6699893.91	1630824.43	364.32	RT90-RHB70	–46.54	144.62	290.7400	–1.2100	28.7900	
474.00	6699892.22	1630825.63	366.50	RT90-RHB70	–46.41	144.69	292.8000	–1.0700	29.2300	
477.00	6699890.53	1630826.83	368.67	RT90-RHB70	–46.24	144.79	294.8600	–0.9300	29.6800	
480.00	6699888.84	1630828.02	370.84	RT90-RHB70	–46.12	144.94	296.9300	–0.7900	30.1400	
483.00	6699887.14	1630829.22	373.00	RT90-RHB70	–46.01	145.08	299.0000	–0.6400	30.6000	
486.00	6699885.43	1630830.41	375.16	RT90-RHB70	–45.94	145.26	301.0800	–0.4900	31.0700	
489.00	6699883.71	1630831.60	377.32	RT90-RHB70	–45.89	145.42	303.1600	–0.3200	31.5400	
492.00	6699882.00	1630832.78	379.47	RT90-RHB70	–45.86	145.59	305.2400	–0.1600	32.0200	
495.00	6699880.27	1630833.96	381.63	RT90-RHB70	–45.80	145.74	307.3300	0.0200	32.4900	
498.00	6699878.54	1630835.14	383.78	RT90-RHB70	–45.72	145.83	309.4100	0.1900	32.9700	
501.00	6699876.81	1630836.32	385.92	RT90-RHB70	–45.58	145.87	311.5000	0.3800	33.4500	
504.00	6699875.07	1630837.50	388.07	RT90-RHB70	–45.44	145.93	313.5900	0.5600	33.9400	
507.00	6699873.33	1630838.67	390.20	RT90-RHB70	–45.31	146.01	315.6800	0.7500	34.4300	
510.00	6699871.58	1630839.85	392.34	RT90-RHB70	–45.22	146.15	317.7800	0.9400	34.9400	
513.00	6699869.82	1630841.03	394.47	RT90-RHB70	–45.10	146.28	319.8900	1.1400	35.4400	
516.00	6699868.06	1630842.21	396.59	RT90-RHB70	–44.98	146.35	322.0000	1.3400	35.9500	
519.00	6699866.30	1630843.38	398.71	RT90-RHB70	–44.86	146.44	324.1100	1.5400	36.4700	

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
522.00	6699864.52	1630844.56	400.83	RT90-RHB70	–44.75	146.53	326.2300	1.7500	37.0000	
525.00	6699862.75	1630845.73	402.94	RT90-RHB70	–44.69	146.54	328.3500	1.9600	37.5300	
528.00	6699860.97	1630846.91	405.05	RT90-RHB70	–44.63	146.56	330.4700	2.1700	38.0600	
531.00	6699859.19	1630848.08	407.16	RT90-RHB70	–44.50	146.61	332.5900	2.3800	38.5900	
534.00	6699857.40	1630849.26	409.26	RT90-RHB70	–44.40	146.74	334.7200	2.6000	39.1400	
537.00	6699855.61	1630850.44	411.36	RT90-RHB70	–44.26	146.90	336.8500	2.8200	39.6800	
540.00	6699853.81	1630851.61	413.45	RT90-RHB70	–44.13	147.03	338.9900	3.0500	40.2400	
543.00	6699852.00	1630852.78	415.54	RT90-RHB70	–44.01	147.15	341.1300	3.2800	40.8000	
546.00	6699850.19	1630853.95	417.63	RT90-RHB70	–43.90	147.27	343.2700	3.5200	41.3600	
549.00	6699848.37	1630855.12	419.71	RT90-RHB70	–43.79	147.40	345.4200	3.7600	41.9300	
552.00	6699846.55	1630856.29	421.78	RT90-RHB70	–43.69	147.54	347.5700	4.0100	42.5100	
555.00	6699844.72	1630857.45	423.86	RT90-RHB70	–43.56	147.67	349.7300	4.2600	43.0900	
558.00	6699842.88	1630858.62	425.92	RT90-RHB70	–43.45	147.79	351.8900	4.5200	43.6700	
561.00	6699841.04	1630859.78	427.99	RT90-RHB70	–43.31	147.87	354.0500	4.7800	44.2700	
564.00	6699839.19	1630860.94	430.04	RT90-RHB70	–43.17	147.97	356.2100	5.0500	44.8600	
567.00	6699837.33	1630862.10	432.10	RT90-RHB70	–43.05	148.07	358.3900	5.3200	45.4700	
570.00	6699835.47	1630863.26	434.14	RT90-RHB70	–42.94	148.18	360.5600	5.6000	46.0800	
573.00	6699833.61	1630864.42	436.19	RT90-RHB70	–42.81	148.29	362.7400	5.8800	46.7000	
576.00	6699831.73	1630865.57	438.23	RT90-RHB70	–42.70	148.45	364.9200	6.1700	47.3200	
579.00	6699829.85	1630866.73	440.26	RT90-RHB70	–42.64	148.61	367.1100	6.4600	47.9500	
582.00	6699827.97	1630867.88	442.29	RT90-RHB70	–42.55	148.81	369.2900	6.7600	48.5800	
585.00	6699826.08	1630869.02	444.32	RT90-RHB70	–42.44	148.96	371.4800	7.0600	49.2100	
588.00	6699824.18	1630870.16	446.35	RT90-RHB70	–42.31	149.05	373.6700	7.3800	49.8500	
591.00	6699822.28	1630871.30	448.37	RT90-RHB70	–42.18	149.19	375.8700	7.6900	50.4900	
594.00	6699820.37	1630872.44	450.38	RT90-RHB70	–42.05	149.29	378.0700	8.0200	51.1400	
597.00	6699818.46	1630873.58	452.39	RT90-RHB70	–41.93	149.39	380.2700	8.3400	51.8000	
600.00	6699816.53	1630874.71	454.39	RT90-RHB70	–41.80	149.48	382.4800	8.6800	52.4600	
603.00	6699814.61	1630875.85	456.39	RT90-RHB70	–41.66	149.60	384.6900	9.0100	53.1300	
606.00	6699812.67	1630876.98	458.39	RT90-RHB70	–41.55	149.74	386.9000	9.3500	53.8000	
612.00	6699808.78	1630879.24	462.36	RT90-RHB70	–41.38	150.02	391.3500	10.0600	55.1700	

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Appendix 4

Length reference marks

Reference Mark T – Reference mark in drillhole

KFM09B, 2005-12-20 00:00:00 (50.000–600.000 m).

Bhlen (m)	Rotation speed (rpm)	Start flow (l/min)	Stop flow (l/min)	Stop pres-sure (bar)	Cutter time (s)	Trace detectable	Cutter diameter (mm)	Comment
50.00	400.00	300	450	30.0	60			JA/JA Spår detekterade Detektering 06-01-23/AU
100.00	400.00	300	450	30.0	120			JA/JA
150.00	400.00	300	450	30.0	100			JA/JA
200.00	400.00	300	450	30.0	120			JA/JA Pump stannade 2 ggr, ersattes av riggens pump vid spårfräsningen
250.00	400.00	300	450	30.0	45			JA/JA
300.00	400.00	300	450	30.0	65			JA/JA
350.00	400.00	300	450	30.0	55			JA/JA
400.00	400.00	300	450	30.0	195			JA/JA
450.00	400.00	300	450	30.0	335			JA/JA
500.00	400.00	800	700	34.0	390			JA/JA
550.00	400.00	800	700	34.0	106			JA/JA
600.00	400.00	750	650	28.0	65			JA/JA Vid ca 530 m upprepade signaler för öppningar.

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