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April 2007

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Abstract

This report presents the results from the Boremap logging of telescopic drilled borehole KFM11A. The borehole is located at the northern shore of Asphällsfjärden, close to the SFR office, and plunges 61° towards NE. The main purpose for the location of this borehole was to provide geological data and spatial information for the so-called Singö fault zone at repository depth, a regionally important deformation zone, which runs NW-SE just southwest of SFR. It has previously been documented in the discharge tunnels from the nuclear power plant as well as the access tunnels to SFR. The full length of KFM11A is 851.21 m. The BIPS-image usable for mapping covers the interval 77.60–846.49 m 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.

KFM11A is drilled outside, northeast of the site investigation area, towards the Singö fault zone. The borehole is located in a ductile to brittle-ductile, high-strain belt, pre-dominated by felsic to intermediate metavolcanic rock, which defines the north-eastern margin of the structurally more homogeneous tectonic lens of rock domain 29.

The predominant metavolcanic rocks, is intensely banded in the upper part of the borehole, but in the lower part it becomes more structure-less and often difficult to distinguish from granitoid rocks, which are also present at these levels. The metavolcanic rock is in the upper part of the borehole intercalated with amphibolite, pegmatitic granite, a fine- to finely medium grained granite and skarn-like occurrences. In the lower part of the borehole aplitic metagranite and the metavolcanic rock predominate. More than 40% of the rocks in the borehole have been affected by alterations of various kinds, the most common types being oxidation, sericitization, epidotization and chloritization. It occurs throughout the borehole.

Virtually all rocks in the borehole have experienced Svecofennian metamorphism under amphibolite facies conditions.

Structurally, KFM11A is characterised by the fact that it penetrates the Singö fault zone. Totally 119 zones of more intense ductile and brittle-ductile deformation have been registered in the borehole. The majority is less than one decimetre wide, but ranges up to several metres and they 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 KFM11A amounts to 12,323, i.e. 15.8 fractures/metre. Of these are 2,905 open, 167 partly open and 9,251 sealed. In addition, there are 330 sealed networks, 25 breccias, 47 sections of crushed rock and 14 cataclastic rocks registered in the mapped interval. The total length of all sealed networks in KFM11A amounts to 132 m. Chlorite and calcite are the most frequent fracture filling minerals found in KFM11A.

Sammanfattning

Föreliggande rapport redovisar resultaten från boremapkarteringen av teleskopborrhål KFM11A. Borrhålet är beläget på norra stranden av Asphällsfjärden, nära SFR:s kontor, och stupar 61° mot NO. Det huvudsakliga syftet med borrhålets placering var att ge geologisk data för den så kallade Singöförkasningen på förvarsdjup. Denna regionalt betydelsefulla förkastning löper i NV-SO strax söder om SFR. Den har tidigare dokumentarats iutloppstunnlarna från Forsmarks kärnkraftverk och i tillfartstunnlarna till SFR. Den totala längden av KFM11A är 851,21 m och den BIPS-bild som är användbar för kartering täcker intervallet 71.60–846.49 m, 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.

KFM11A har borrats strax nordöst om undersökningsområdet, mot Singöförkastningen. Borrhålet penetrerar en duktil till spröd-duktil deformationszon, dominerad av felsiska till intermediära metavulkaniter, som utgör den nordöstra gränsen på den strukturellt mer homogena tektoniska linsen i bergartsdomän 29.

Den dominerande metavulkaniten är intensivt bandad i de övre delarna av borrhålet, men blir mer strukturlös längre ner och där ofta svår att särskilja från granitoida bergater som också förekommer här. Metavulkaniten är i den övre delen av borrhålet växellagrad med amfibolit, pegmatitisk granit, en fin till fint medelkornig granit och med skarnlika förekomster. I den undre delen av borrhålet dominerar aplitisk metagranit tillsammans med metavulkaniten. Mer än 40 % av borrhålets bergarter har drabbats av olika typer av omvandling. De vanligaste typerna är oxidering, serisitisering, epidotisering och kloritisering. Omvandling förkommer på alla djup.

Största delen av berggrunden i området har genomgått Svekofennisk amfibolitfacies-metamorfos.

Strukturellt är KFM11A karaktäriserad av det faktum att borrhålet penetrerar Singöförkastningen. Totalt 119 duktila och spröd-duktila deformationszoner har registrerats. En majoritet av dessa är under 1 decimeter, men vissa är flera meter i borrhålslängd. De är mer eller mindre parallella med den lokala foliationen.

Det totala antalet sprickor som registrerats under karteringen av KFM11A, *utöver krosszoner och läkta nätverk,* är 12 323, det vill säga 15,8 sprickor/meter. Av dessa är 2 905 öppna, 167 delvis öppna och 9 251 läkta. Utöver detta förekommer 330 läkta nätverk, 25 brexior, 47 sektioner med krossat berg och 14 kataklastiska bergarter i det karterade intervallet. Den totala längden för läkta nätverk utgör 132 m. Klorit och kalcit är de två vanligaste mineralen som påträffats i KFM11A.

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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 and spatial information for the so-called Singö fault zone (ZFMNW0001), a regionally important deformation zone, which runs NW–SE just southwest of SFR. It has previously been documented in the discharge tunnels from the nuclear power plant as well as the access tunnels to SFR. To obtain more detailed information at repository level, borehole KFM11A was drilled near the SFR entrance building north of the site investigation area, with 61° inclination towards northeast (040°) (Figure 1-1). The borehole has a total length of about 851 m.

The drilling activities in KFM11A were finished 16 November 2006, and the geological logging of the borehole started 10 October 2006 and ended 12 March 2007.

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 KFM11A, 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 400-06-094. In Table 1-1 controlling documents for performing this activity are listed. Both activity plan and method descriptions are SKB's internal controlling documents.

Original data from the reported activity are stored in the primary database Sicada, where they are traceable by the Activity Plan number (AP PF 400-06-094). Only data in SKB's databases are accepted for further interpretation and modelling. The data presented in this report are regarded as copies of the original data.Data in the databases may be revised, if needed. Such revisions will not necessarily result in a revision of the P-report, although the normal procedure is that major data revisions entail a revision of the P-report. Minor data revisions are normally presented as supplements, available at *www.skb.se*.

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

Activity plan	**Number**	**Version**
Boremapkartering av borrhål KFM11A	AP PF 400-06-094	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 Bergartsanalyser	SKB MD 160.001	1.0

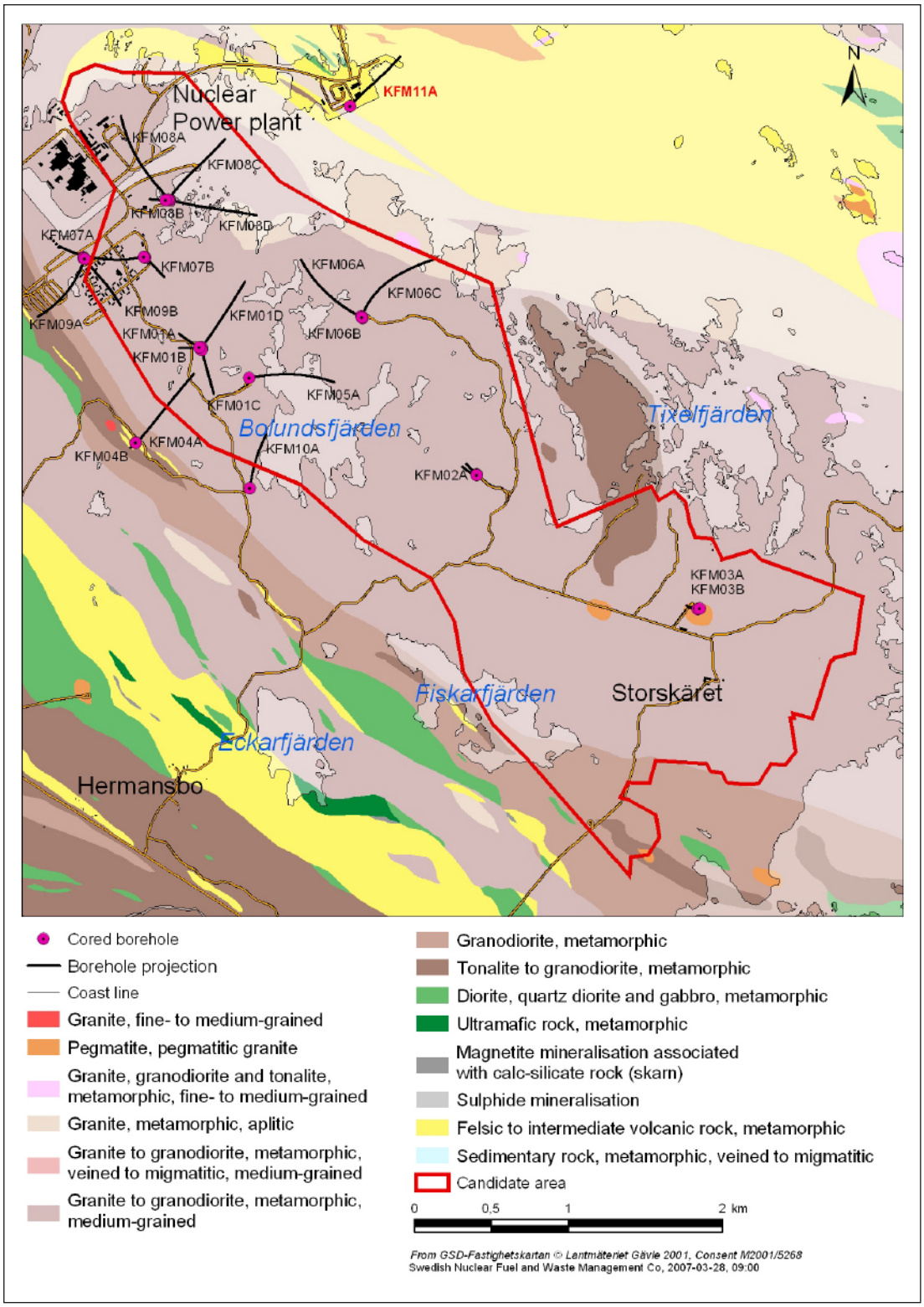


Figure 1-1. *Generalized geological map over Forsmark site investigation area and the projection of KFM11A in relation to other cored boreholes in the drilling programme.*

2 Objective and scope

The bedrock starts at 6.3 m length in borehole KFM11A. The borehole starts with percussion drilling to a length of 71.06 m, followed by core drilling of Ø = 86 mm to 72.81 m, and from there down to its full length at 851.21 m. The diameters of the drill cores are 70 and 51 mm, respectively, under ideal conditions. Only the part drilled at Ø = 77.3 mm was included in the mapping engagement and the BIPS-image usable for geological logging covers the length interval 71.60–847.30 m (after length adjustment 71.60–846.49 m). Thus, remaining part of the drill core, from 847.30 to 851.15 m (after length adjustment 850.90 m), was mapped in 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 = 77.3 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. In order to obtain compositional documentation of the two main rock units in the borehole, the work includes also modal analyses of three thin-sections.

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.

Modal analysis was carried out at the Earth Sciences Centre, Göteborg University, using a standard polarizing microscope with attached point counter equipment.

4 Execution

4.1 General

During the core logging, the 780 m drill core obtained from the interval 71.06–851.15 m of KFM11A 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 KFM11A 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. However, three thin-sections of the main rock units were prepared as a rough verification after the mapping was finished. 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 KFM11A was performed in Boremap v. 3.754 according to activity plan AP PF 400-06-094 (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.

Three polished thin-sections, from 4 cm long core sections, were prepared by Ali Firoozan, Earth Sciences Centre, Göteborg University. The modal analysis was done by Jesper Petersson (Vattenfall Power Consultant AB) by determining the mineral composition at 500 evenly spaced points over each thin-section.

The Boremap-mapping of the borehole is summarised in a WellCAD diagram 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 856 m borehole length of KFM11A is about 8 dm. It was, therefore, necessary to adjust the length in KFM11A with reference to groove millings cut into the borehole wall at every 50 m. The deepest slot was cut at 801 m length, though this slot was not detectable in the BIPS-image. 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 250 m 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 remaining part of KFM11A. 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 1 dm in the upper 650 m of the borehole and 2 dm below that level. *All borehole lengths given in this report are length 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 diagrams 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. Generally, they are still oriented relative to other structures with known orientations. There is, however, an interval of poor BIPS-image quality, between two crushes at 600.56–601.66 m adjusted length, where all registered features are non-oriented. Fractures that are obviously drilling-induced 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 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, 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 following intervals in KFM11A: 282.87–282.92, 544.70–544.79, 620.41–620.51, 626.00–626.11, 637.15–637.28, 657.53–657.66, 671.71–671.87, 672.07–672.11, 712.21–712.23, 753.27–753.32 and 756.10–756.12 m adjusted length. In addition, there are several core losses: 219.97–219.98, 327.57–327.73, 464.80–464.92, 472.98–473.04, 523.84–524.05, 592.31–593.44, 598.72–600.56, 605.15–605.49 and 653.87–654.20 m adjusted length. All are inferred to be of mechanical nature. A gap of 43 cm between the two BIPS-images at 559.46–559.89 m adjusted length was also registered as 'core loss'.

4.5 Nonconformities

Several fractures within KFM11A 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 several previous cored boreholes, the mapping of KFM11A was somewhat hampered by a low quality image. Brownish to black coatings occur along the whole borehole and the explanation proposed is that the coatings originate from metal fragments abraded from the drill rods. Light and dark, vertical narrow streaks also occur along the whole image. Finally, most of the image shows a fuzzy appearance and lacks desired sharpness and contrast (Figure 4-1), which often renders the identification of individual fractures, contacts etc difficult. The dark coating occurs throughout the borehole and forms typically a patchy pattern in a band along the borehole axis. Still, most fractures can be distinguished and the banded appearance of the rock in a large part of the core, support the identification and orientation of objects.

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 KFM11A, though there might still be unnoticed errors. We disclaim the responsibility for all errors caused by the shortcomings in the software.

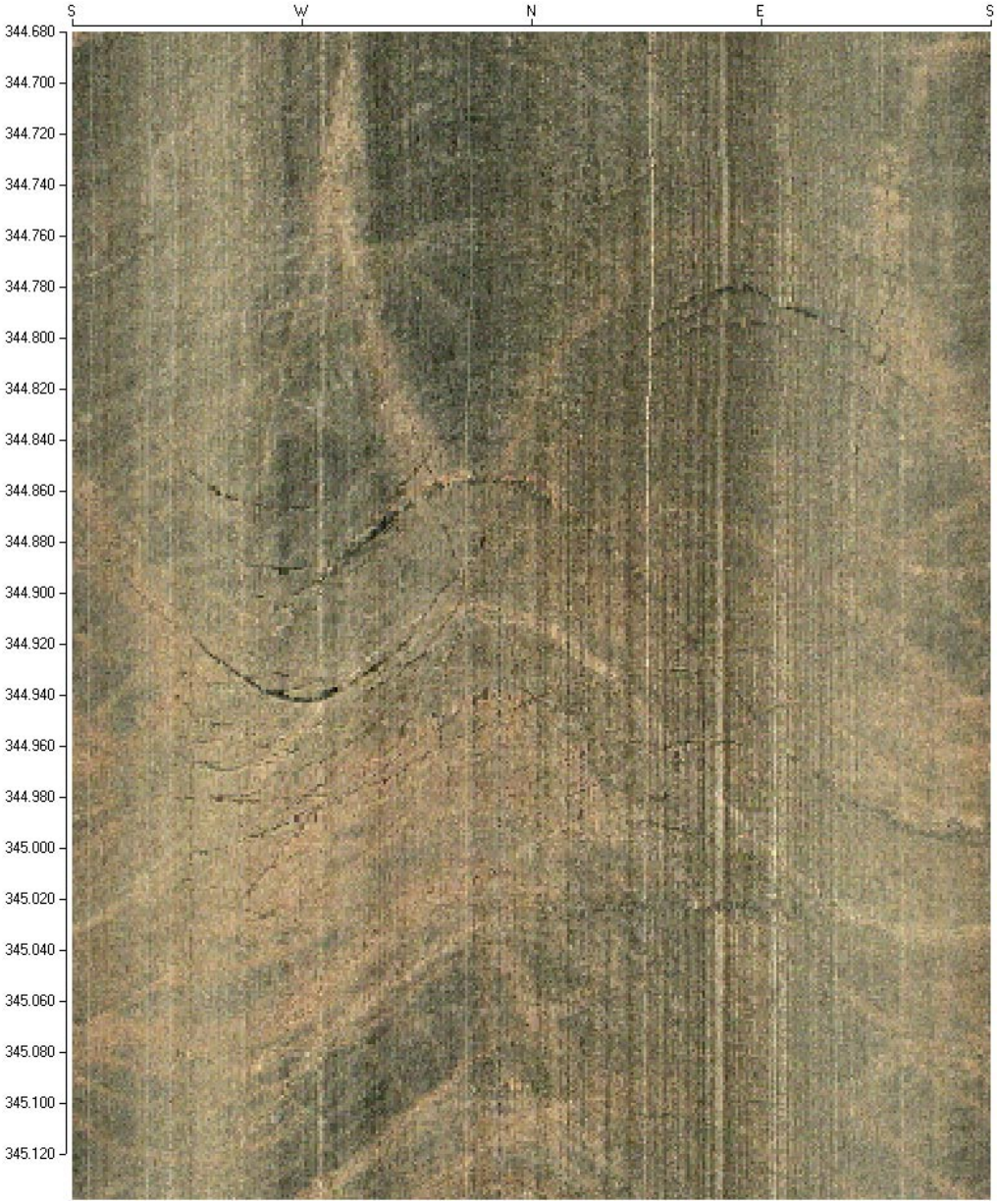


Figure 4-1. *A representative example of the BIPS image quality.*

5 Results

5.1 Lithology

5.1.1 General

Borehole KFM11A is located in the ductile, high-strain belt of predominantly metavolcanic rocks, which defines the northeastern margin of the structurally more homogeneous tectonic lens of rock domain 29 /cf SKB 2005/. It was drilled with a plunge ranging from approximately 60 to 51° towards northeast, (i.e. more or less perpendicular to structural trend in the area) into the NW-SE striking Singö fault zone (ZFMNW0001). Down to about 585 m length, KFM11A penetrates an intensely deformed sequence of felsic to intermediate metavolcanic rocks (rock code 103076), intercalated with amphibolites (rock code 102017), minor skarn-like occurrences (rock code 108019) and later occurrences of pegmatitic granite (rock code 101061) and fine- to finely medium-grained granite (111058). Further down, to the end of the borehole, there is a predominance of aplitic metagranite (rock code 101058) and felsic to intermediate rocks of inferred volcanic origin (rock code 103076). Additional rock units that form continuous occurrences of volumetric importance in this part of KFM11A include a fine- to finely medium-grained granite (rock code 111058) at 703–725 m, a pegmatitic granite (rock code 101061) at 802–812 m and a fine- to finely medium-grained metagranitoid (rock code 101051) of granodioritic to tonalitic composition at 822–851 m length. Other frequent rock types in this lower interval, none forming occurrences more than a few metres in borehole length, are various amphibolites as well as dykes and veins of pegmatites, pegmatitic granite and fine- to finely medium-grained granite. Except for a few minor late veins, all rocks have experienced Svecofennian metamorphism under amphibolite facies conditions.

5.1.2 Rock types

Felsics to intermediate metavolcanic rocks (rock code 103076) are found throughout the borehole, but are most prevalent down to about 585 m length in the borehole. The rock is generally equigranular, dark grey to reddish grey in colour and all contacts are parallel with the tectonic fabric. In the upper 410 m, they show a characteristic fine-scale compositional banding. Below that level, they become more structureless, and except for the grain-size, there is no textural or structural macroscopic feature that unambiguously points towards a volcanic origin of the rocks. Some of these more homogeneous varieties are slightly feldspar porphyritic. Modal analyses of two representative samples, one with the fine-scale compositional banding (sample ID 374) and one more homogeneous rock (sample ID 375), reveal that the rock mostly is quartz- andecitic in composition (Table 5-1). Rather coarse garnet, up to about eight millimetres in diameter, can locally be distinguished in the interval between 230 and 410 m length. Inferred metavolcanic rocks that occur below 585 m length are in some intervals difficult to separate from both the aplitic metagranite (rock code 101058) and more fine-grained varieties of the metagranite-granodiorite (rock code 101057).

All mafic rocks within KFM11A, except for some skarn-like material, are registered as amphibolite (rock code 102017). Generally, the amphibolites are fine-grained, equigranular with a large proportion of biotite. There is, however, a considerable variability in the textural and structural character of the rocks. Both the lithological association with more intermediate volcanic rocks and skarn-like material, as well as a fine-scale compositional banding in some occurrences, suggest that they are of volcanic or subvolcanic origin. Except for a major occurrence at 356.7–374.6 m length, all continuous amphibolites of volumetric importance are restricted to the uppermost 191 m of the borehole, where they often are intimately associated

Table 5-1. Modal analyses of thin-sections from borehole KFM11A.

Adjusted length (m) Core length (m) Sample ID	295.360–295.401 295.41–295.45 374	419.312–419.350 419.25–419.29 375	642.792–642.830 642.90–642.94 376
Rock type	Intermediate metavolcanic rock	Intermediate metavolcanic rock	Aplitic meta-granite
Rock code	103076	103076	101058
Quartz	14.4	25.6	32.0
K-feldspar	2.0	–	49.6
Plagioclase [1]	48.4	57.2	12.6
Biotite	0.4	–	0.2
Muscovite	–	–	0.2
Chlorite	+	16.8	3.0
Hornblende	29.2	–	–
Epidote	3.8	0.2	1.8
Allanite	+	–	+
Prehnite	–	–	+
Sphene	1.4	–	–
Calcite	0.4	–	–
Apatite	+	+	+
Zircon	–	–	+
Opaque	+	0.2	0.6

+ = trace amounts.

[1] Including sericitised plagioclase.

with skarn-like rocks. Less extensive amphibolites, none forming occurrences more than a few metres in borehole length, occur sporadically throughout KFM11A. Most lacks compositional banding and all contacts are more or less parallel with the tectonic fabric.

The occurrence of skarn-like material (rock code 108019) is generally concentrated to the uppermost 167 m of the borehole. Additional occurrences outside this interval are rare and the volumetrically most important is found at 662.5–666.3 m length. Individual occurrences are distinguished by their high content of epidote. Other frequent components are quartz, whitish feldspar, hornblende and magnetite. The external contacts are typically rather sharp. Occurrences with more gradual contacts towards the surrounding amphibolite/metavolcanic rock are generally registered as the alteration ‘epidotization’ instead (see below).

Aplitic metagranite (rock code 101058) predominates between 585 and 822 m length. However, it is locally difficult to separate from the more felsic varieties of the metavolcanic rocks, which are inferred to occur in the length interval 660–783 m. The aplitic metagranite is typically equigranular, greyish red to grey in colour and with a biotite content less than 10 vol. %. The modally analyzed sample consists of almost 50% perthitic K-feldspar and about 5% mafic mineral phases (Table 5-1). All lithological contacts are parallel with the tectonic fabric.

A few occurrences of fine- to finely medium-grained metagranite-granodiorite (rock code 101057) have been registered in the borehole. The majority is restricted to the length interval 716–779 m. Three additional occurrences, exceeding one metre, occur outside this interval. Texturally, the rock is rather equigranular with elongated quartz domains, alternating with feldspar-dominated domains and thin streaks of biotite. However, this texture is definitely vaguer than in the typical medium-grained metagranite-granodiorite that the dominating rock type rock domain 29. The colour of the rock ranges from greyish red to grey. In addition, there are two major occurrences at 561.2–568.4 and 570.3–572.1 m, which are granodioritic in composition, and thus mapped as medium-grained metagranodiorite (rock code 101056).

Dykes, veins and segregations of pegmatite and pegmatitic granite are frequent throughout KFM11A. Most occurrences are some decimetre or less, but several pegmatites/pegmatitic granites exceed a few metres in borehole length. The most extensive occurrences of pegmatitic granite occur at 498.9–510.4 and 802.0–812.0 m adjusted 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. Various sulphides, primarily pyrite, have been identified in a few pegmatites. Despite the textural variability and temporal span within this unit, most of these rocks were grouped as 'pegmatite, pegmatitic granite' (rock code 101061).

Fine- to medium-grained metagranitoids (rock code 101051) of mostly granodioritic to tonalitic composition are largely restricted to an extensive occurrence in the lowermost part of KFM11A, at 822.1–845.3 m length. Two additional occurrences exceeds one metre in borehole length, whilst the other are up to 1–2 dm in length. These rocks are equigranular, locally slightly feldspar 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. Several 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 throughout the borehole. Similar to the granodioritic to tonalitic metagranitoids, they are typically equigranular with linear mineral fabric and discordant external contacts. A distinctive criterion apart from their granitic composition and late-tectonic character is their anomalously high natural gamma radiation relative to the granodioritic to tonalitic metagranitoids /cf Mattsson and Keisu 2006/. The three most extensive occurrences occur at 273.9–281.7, 352.5–356.7 and 752.6–757.5 m length. The other occurrences range up to a few metres in borehole length.

In addition, there are a few minor occurrences of tonalite, granodiorite, and 'granitoid' in KFM11A. None of them appears to fit into the bedrock nomenclature defined by SKB MD 132.005. Instead they were coded as 1053 (unspecified tonalite), 1056 (unspecified granodiorite) and 1051 (unspecified 'granitoid'). Quartz-dominated segregations or veins were coded as 8021, whereas feldspar–quartz-dominated segregations or veins were coded as 8020. Six minor sulphide mineralized sections are recorded in the borehole. Except for one occurrence at 260.80–261.11 m length, they are all about one centimetre in borehole length. An aplite found at 823.47–823.53 m adjusted length, which appears unaffected by the fabric development, was coded as 1062.

5.2 Ductile structures

The rocks in KFM11A are characterized by a medium to strong foliation. Some of the pegmatitic granites (rock code 101061), the fine- to finely medium-grained metagranitoid (rock code 101051) and the fine to medium-grained granite (rock code 111058) instead show a faint to weak lineated fabric (at a few locations medium intensity). Notably only three short sections in KFM11A have a massive appearance, all three in Pegmatite (rock code 101061), at 131.11–132.42, 397.14–398.26 and 423.63–426.13 m adjusted length. In the upper part of the borehole (between ca 90 and 350 m core length) a more or less pronounced banding occurs, particularly related to felsic to intermediate metavolcanic rocks (rock code 103076) and amphibolites (rock code 102017). It has a faint to weak intensity. Parallel to the banding there is a foliation, expressed by a grain-shape preferred orientation, which also is parallel to the local foliation found in 'Rock Types' and 'Rock Occurrences' (cf Figure 5-1). Since the metavolcanic rock has been recrystallised it is difficult to estimate how much of the fine-scale banding that may be a result of deformation (folding and stretching) and metamorphic segregation, and how a primary banding might have been preserved.

It must 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 pegmatitic granites and some of the fine-grained mafic rocks. Furthermore, most rocks have undergone varying degrees of static recrystallization. The structural orientation in KFM11A is rather consistent throughout the hole, striking NW-SW and the dip is steep either to the SE or to the NE. Linear fabrics are not possible to register with the present methodology.

Totally 119 zones of ductile and brittle-ductile deformation have been registered in KFM11A. Fifty-two of these are of intermediate to strong intensity. Thirty-three of the shear zones are of ductile character, whereas the others are brittle-ductile. The zones occur throughout KFM11A and seem to affect all rock types. The borehole length of individual zones is typically less than one decimetre, though the maximal recorded length is 6.96 m. The ductile deformation in the shear zones is parallel to the general structural trend in KFM11A (Figure 5-1 and Appendix 1).

5.3 Alteration

Approximately 42% of KFM011A has been affected by alteration. Of this 37% is mapped as alteration in Boremap. In addition to this, alterations that are mapped as fracture minerals should be added, which include oxidized and epidotized walls. There are over 4,300 fracture walls affected by these kinds of alterations. No width of the alteration around fractures have been measured, but a rough estimate of 1 cm as an average add about 5% of altered borehole length.

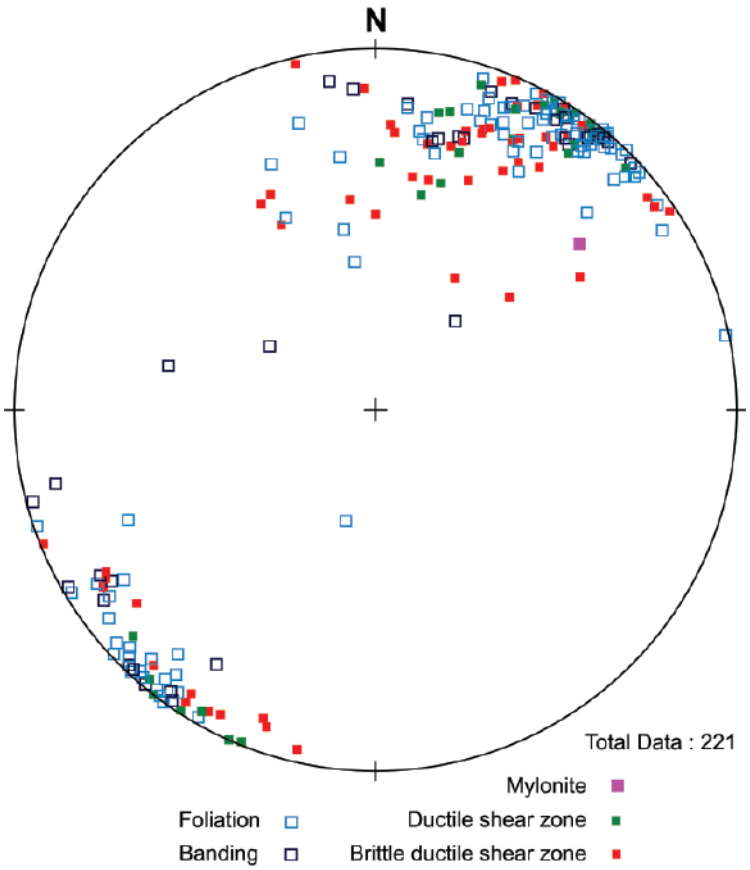


Figure 5-1. *Lower hemisphere, equal area stereographic projection showing poles to ductile structures and banding in KFM11A.*

The most common alteration encountered in KFM11A is varying degrees of oxidation or red pigmentation of feldspars by sub-microscopic hematite. Totally, about 15% of the mapped interval of KFM11A and a total of 4,278 fractures (oxidized walls) have been affected by oxidation. Normally the oxidation is faint to weak in intensity, but a more intensely altered section can be distinguished between about 500–585 m adjusted length, where medium intensity is common.

Other types of alterations within KFM11A in order of decreasing abundance include sericitization, epidotization, chloritization, albitization, steatitization, laumontitization, argillization, carbonatization and an alteration that gives the rock a slightly darker, blurry appearance (mapped as 'sassuritization' in Boremap). Calcite-rich intervals are marked as 'carbonatization' and talc-rich intervals as 'steatitization'.

Clay alteration (argillization) is not very common (totally 1.1 m borehole length), but a 0.76 m long section occurs at 612.63–613.39 m adjusted length. The steatitization is preferentially located between about 510 and 550 m adjusted length, and amounts to more than 10 m. Laumontitization occurs sporadically at shorter length intervals in the borehole, the longest at 498.92–500.70 m adjusted length. The about 116 m of sericitisation are distributed throughout the borehole. Epidotization (totally 35.4 m) preferentially occur in the upper 500 m of the borehole and is less common below that level. Chloritization occurs in the whole borehole, but is localised to amphibolites (rock code 102017) and to the felsic to intermediate volcanic rock (rock code 103076). Albitization, finally is rather frequent at 120–152 m adjusted length, but occur otherwise only in sporadic, short length intervals.

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 KFM11A amounts to 12,323, i.e. about 15.8 fractures/metre. This is very high compared to other deep boreholes in the area. Of these are 2,905 open, 167 partly open and 9,251 sealed. The 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.

One wide fracture, mainly filled with calcite, at 798.13–798.22, is mapped as an occurrence.

In addition, there are 330 sealed networks, 25 breccias, 47 sections of crushed rock and 14 cataclastic rocks registered in the mapped interval. The distinction between breccia and sealed network is not straight forward, but normally zones with none or minor rotation of individual rock fragments have been mapped as sealed network. 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 KFM11A amounts to 132.0 m (i.e. approximately 17% of the mapped interval). The piece length (i.e. the distance between individual fractures) within these networks is typically 1–2 cm, but ranges up to 5 cm. This makes about 9,000 additional sealed fractures in the mapped interval of the borehole. Several of the sealed networks exceeds 0.5 m, the longest (> 1 m) are located at 374.74–376.08, 492.70–498.15, 498.16–499.22, 582.85–510.84, 511.55–513.69, 514.51–515.98, 525.10–526.41, 526.41–527.49, 593.53–596.26, 597.51–598.72, 607.60–609.16, 619.99–622.27, 635.86–637.77, 675.00–676.82, 698.95–700.25, 716.18–718.70, 730.33–731.97, 732.69–735.86, 740.65–741.46, 747.09–748.72, 758.60–761.03, 765.93–767.61, and 796.80–798.23 m adjusted length.

Non of the breccias exceeds one metre in length and sections longer than one decimetre occurs at the following lengths within KFM11A: 454.08–454.21, 487.15–487.32, 498.60–489.91, 492.68–492.82, 497.72–498.07 and 498.35–498.88 m adjusted length. The longest section slightly exceeds 0.6 m.

There are 71 faults registered in KFM11A, related to fractures and sealed network. This is noted in comments attached to each of these fracture and networks.

The total length of crushed rock (drill induced excluded) amounts to 8.52 m, with two sections exceeding 0.5 m at 592.06–593.45 and 598.47–600.56 m adjusted length. The piece lengths range from only a few millimetres up to 4 cm in the crush zones.

Throughout the borehole, the frequency of open and sealed fractures varies rather coherently (Appendix 1). In fact, the major part of the core has a very high fracture frequency and in sections where the frequency of sealed fractures is lower, there are sealed networks instead. Only in the section between about 180 and 250 m there are significantly less open fractures than in the rest of the core.

Inferred core discing occurs at the following lengths along KFM11A: 581.82, 581.87, 393.75–394.17, 496.77, 496.81, 594.39, 594.43, 594.50–595.15 and 726.21–726.50 m adjusted length. One of the core discing sections is only initial and do not actually break the core. The maximum width of the intervals is 6.6 dm, and the dimension of individual discs is 12–15 mm. The discs are all planar to slightly saddle-shaped.

5.4.2 Fracture mineralogy

Chlorite and/or calcite are found in about 73% of the total number of the registered fractures in KFM11A. Other infilling minerals, in order of decreasing abundance, include laumontite, adularia, epidote, quartz, white feldspar, sub-microscopic hematite, clay minerals, and more rarely talc (mapped as X1), muscovite and sericite, prehnite, apophyllite (mapped as X3), pyrite and four fractures with probable gypsum (mapped as X4). In addition, there are 21 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 351 fractures that are virtually free from visible mineral coatings. Of these 136 are unbroken, sealed fractures with no *visible* mineral sealing.

Talc preferentially occurs in the interval 510–560 m adjusted length, in the same length interval where the alteration ‘steatitization’ is common (see section 5.3).

The various clay minerals occur generally in open fractures. Fractures with clay minerals are found throughout the borehole. Another mineral preferably found in open and partly open fractures is Fe-hydroxide, found in 13 fractures.

Sulphides are frequent in both sealed and open fractures. The presence of other sulphides than pyrite, such as pyrrhotite and ‘unspecified sulphides’, are rare and restricted to 19 fractures. Another rare mineral, apophyllite (15 fractures), also occur in both sealed and open fractures.

All other minerals, as well as oxidized walls, are preferentially associated with fractures inferred to be sealed.

Laumontite, typically associated with calcite, has been recorded in a total of 2,388 fractures. It occurs throughout the borehole except for a section between about 255 and 300 m length. 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.

References

Mattsson H, Keisu M, 2006. Forsmark site investigation. Interpretation of geophysical borehole measurements from KFM08C, KFM10A, HFM30, HFM31, HFM33, HFM34, HFM35 and HFM38. SKB P-06-XX, Svensk Kärnbränslehantering AB.

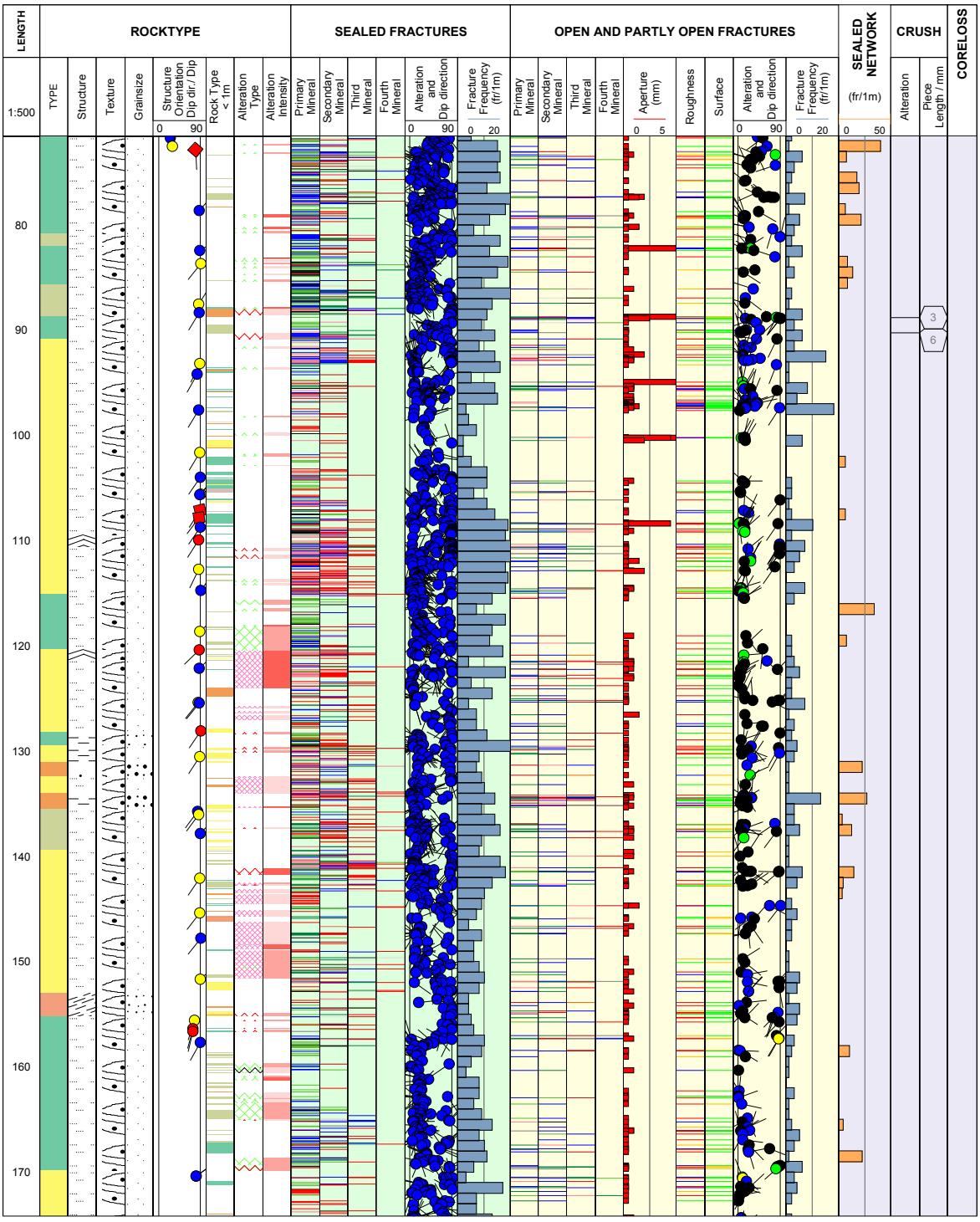
Sandström B, Savolainen M, Tullborg E-L, 2004. Forsmark site investigation. Fracture mineralogy: Results of fracture minerals and wall rock alteration in boreholes KFM01A, KFM02A, KFM03A and KFM03B. SKB P-04-149, Svensk Kärnbränslehantering AB.

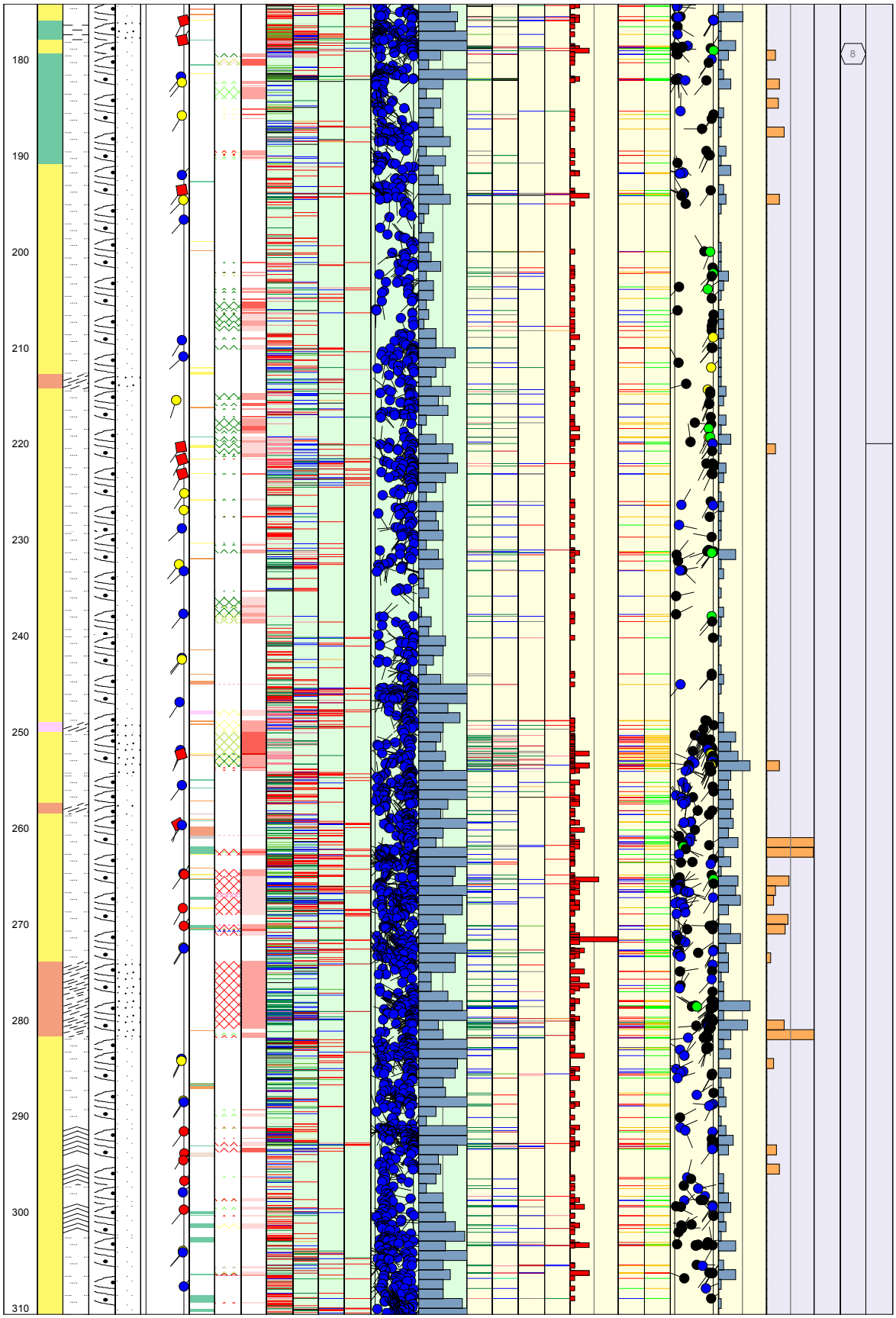
SKB, 2005. Preliminary site description. Forsmark area – version 1.2. SKB R-05-18, Svensk Kärnbränslehantering AB.

WellCAD image

Title GEOLOGY IN KFM11A **Appendix:**

Site	FORSMARK	**Coordinate System**	RT90-RHB70
Borehole	KFM11A	**Northing [m]**	6701103.82
Diameter [mm]	77	**Easting [m]**	1632366.75
Length [m]	851.210	**Elevation [m.a.s.l.]**	2.95
Bearing [°]	40.25	**Drilling Start Date**	2006-08-29 08:00:00
Inclination [°]	-60.93	**Drilling Stop Date**	2006-11-20 00:00:00
Date of coremapping	2006-10-10 08:23:00	**Plot Date**	2007-05-28 23:02:23
Rocktype data from	p_rock	**Signed data**	

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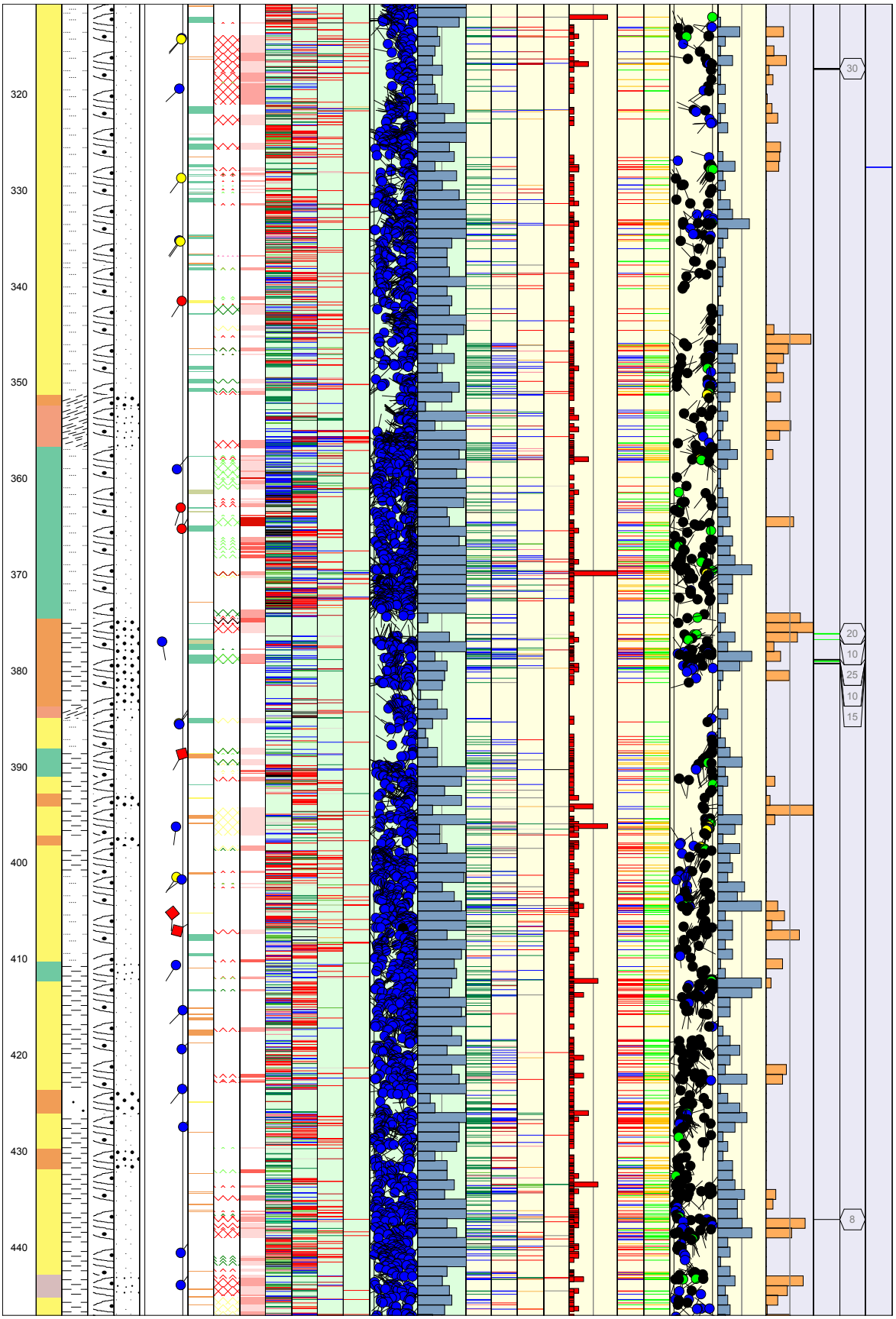
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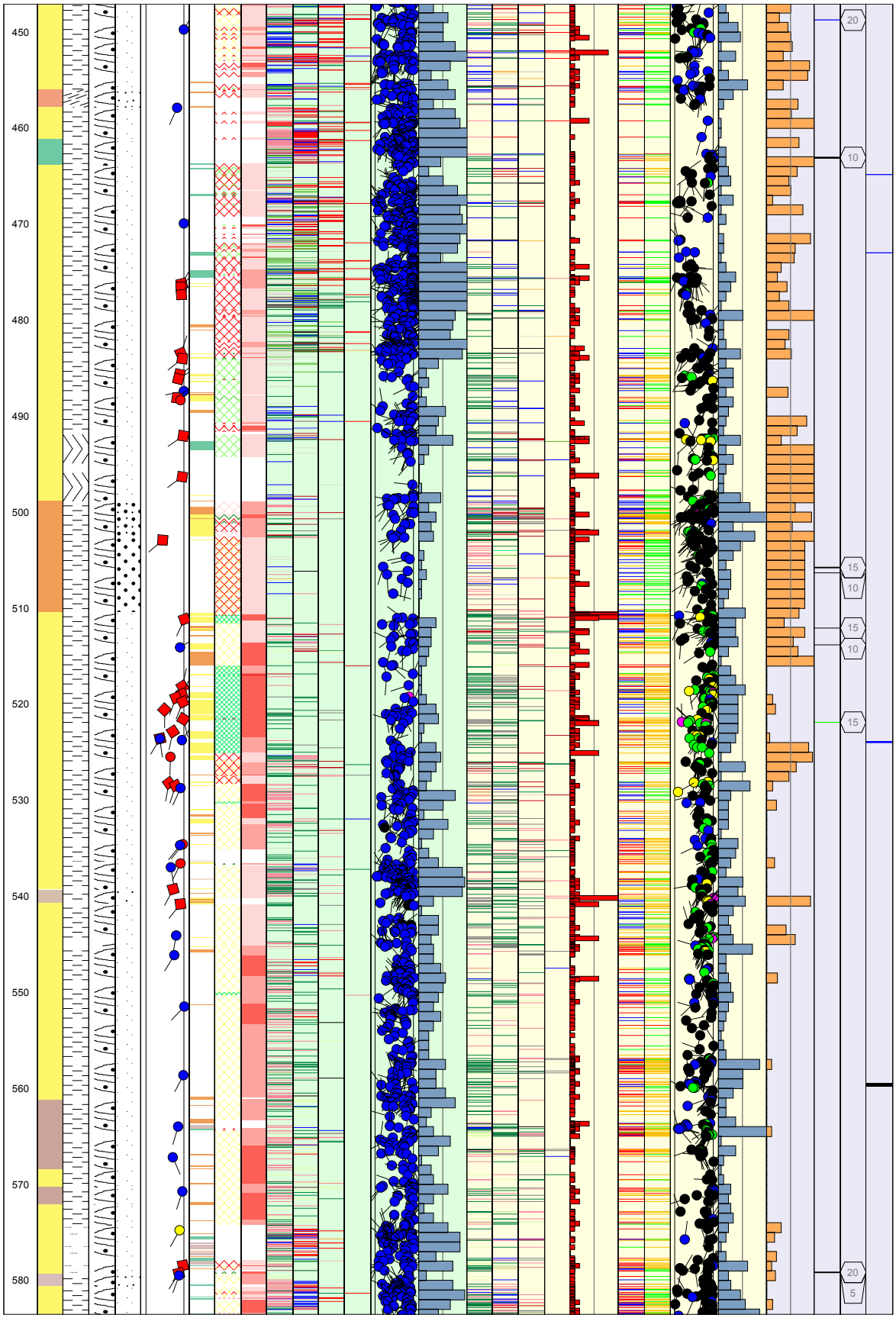
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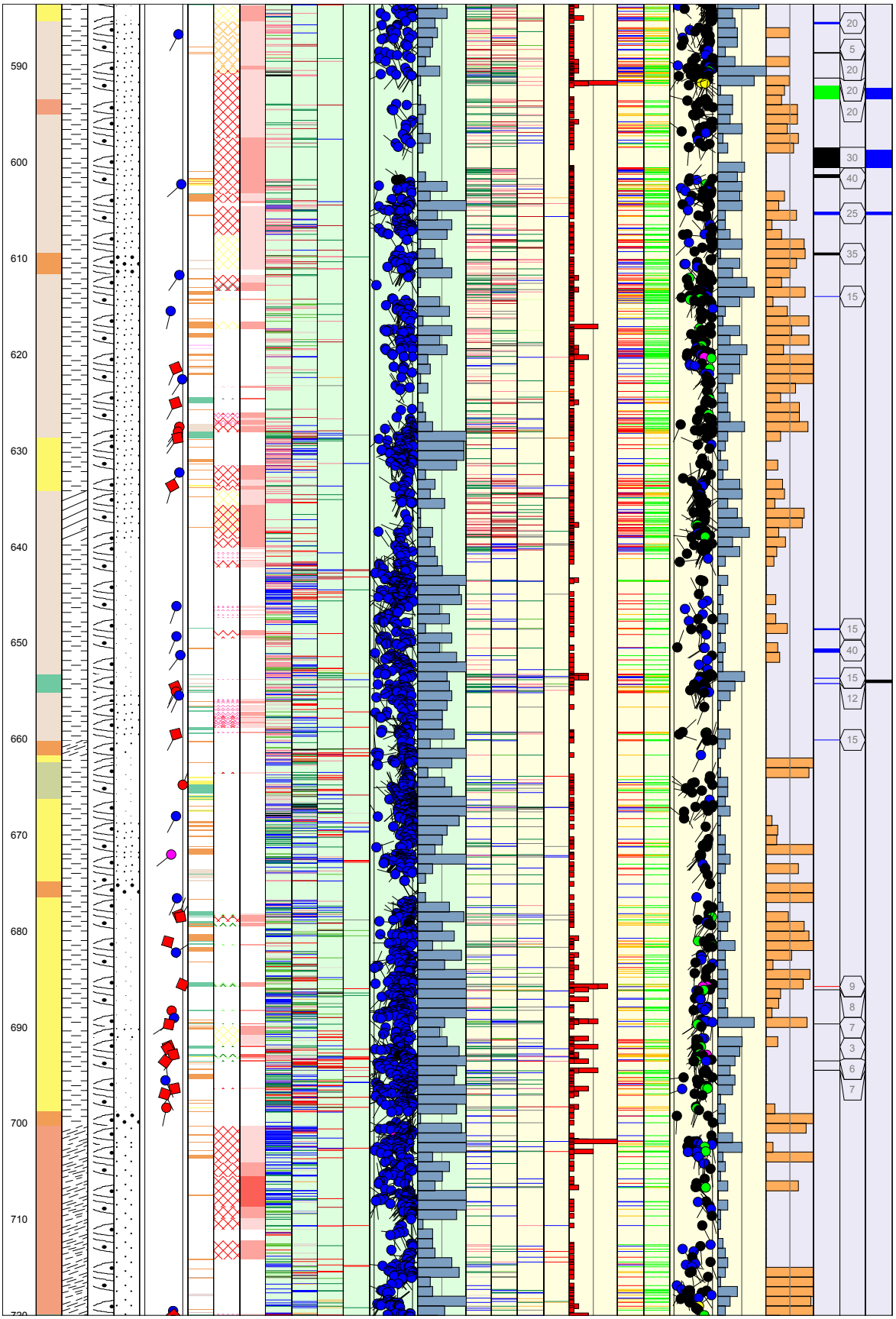
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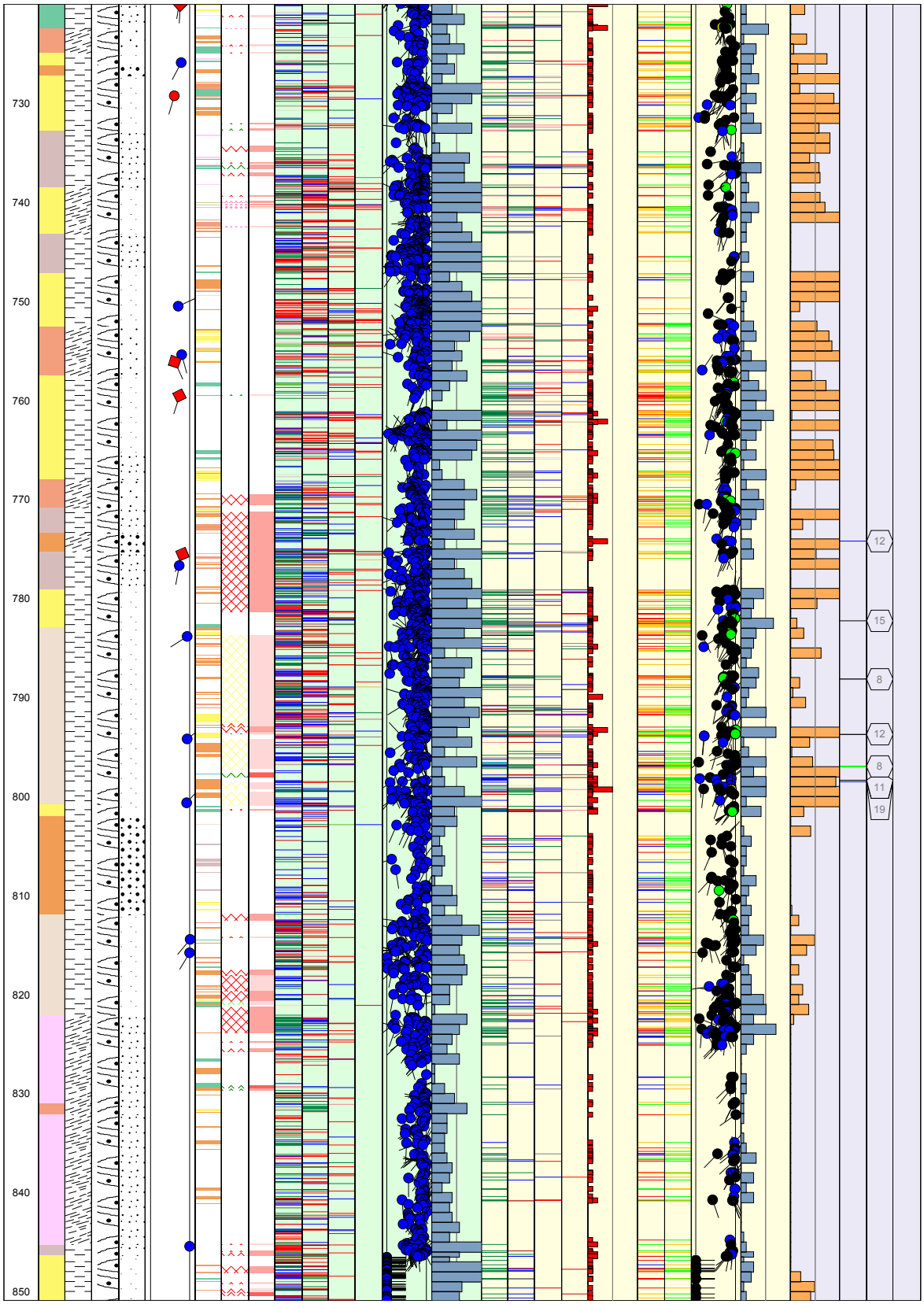
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Appendix 2

Borehole diameters

Hole diam T – Drilling: Borehole diameter

KFM11A, 2006-08-29 08:00:00 – 2006-11-20 00:00:00 (71.060–851.210 m)

Sub secup (m)	Sub seclow (m)	Hole diam (m)	Comment
71.060	72.810	0.0860	
72.810	851.210	0.0773	Dummy kvar i borrhålet. Borrhålet är fritt till 848 m.

Printout from SICADA 2007-03-29 17:34:07.

Appendix 3

Downhole deviation measurements

Magnetic acc dev T – Magnetic accelerometer deviation measurement

KFM11A, 2006-11-28 16:25:00 – 2006-11-28 19:20:00 (3.000–840.000 m)

Bhlen (m)	Dip (degrees)	Magnetic bearing (degrees)	Easting (m)	Northing (m)	Elevation (m)	Mag-field (nT)	Magdip (degrees)	Grav-field	Toolroll (degrees)	Magtool-face (degrees)	Dls (degrees/ m)	Dls 30 (degrees/ 30 m)	Status	Magh (nT)	Magv (nT)	Up-down (m)	Left-right (m)	Shortfall (m)
3.00	–60.97	38.03			0.000	66281	58.19	1.0000	336.48	333.78	0.000		3	34935.0	56327.0	0.00	0.00	0.00
6.00	–60.80	38.08			–2.620	53548	61.13	1.0003	339.50	241.02	1.935		3	25856.0	46892.0	–0.01	–0.15	–0.01
9.00	–60.68	38.14			–5.270	20001	67.09	1.0002	336.60	105.38	6.828		3	7786.0	18423.0	–0.10	0.07	–0.03
12.00	–60.64	38.19			–7.890	78838	68.97	1.0001	338.68	121.04	1.580		3	28296.0	73585.0	–0.22	0.71	–0.10
15.00	–60.58	38.24			–10.500	52858	70.59	1.0003	341.80	123.63	1.553		3	17569.0	49853.0	–0.33	1.35	–0.18
18.00	–60.74	38.30			–13.120	51666	71.37	1.0000	341.52	123.34	0.870		2	16507.0	48958.0	–0.53	2.16	–0.29
21.00	–60.94	38.35			–15.740	50678	71.03	1.0000	344.02	123.40	0.555		2	16475.0	47925.0	–0.79	3.05	–0.44
24.00	–61.18	38.40			–18.360	50365	69.75	1.0003	324.36	99.80	0.464		2	17433.0	47252.0	–1.06	3.94	–0.59
27.00	–61.38	38.45			–20.990	50608	73.22	1.0001	328.43	115.10	0.233		0	14611.0	48453.0	–1.31	4.78	–0.72
30.00	–61.56	38.51			–23.630	50961	72.07	1.0001	332.23	114.25	0.329		0	15691.0	48485.0	–1.58	5.62	–0.85
33.00	–61.73	38.56			–26.270	50192	72.05	1.0003	337.17	119.26	0.229		0	15470.0	47748.0	–1.85	6.47	–0.99
36.00	–61.89	38.61			–28.910	50874	72.55	1.0001	327.65	109.79	0.655		0	15253.0	48533.0	–2.16	7.33	–1.13
39.00	–62.11	38.67			–31.560	50701	72.50	0.9999	330.48	112.46	0.262		0	15243.0	48355.0	–2.49	8.22	–1.28
42.00	–62.38	38.72			–34.220	49357	76.34	1.0000	337.28	134.88	1.618		3	11657.0	47961.0	–2.76	8.98	–1.39
45.00	–62.52	38.77			–36.880	49803	77.03	1.0004	339.78	141.90	0.788		3	11177.0	48532.0	–2.95	9.57	–1.46
48.00	–62.68	38.82			–39.550	50885	71.37	0.9998	341.91	118.75	2.538		2	16253.0	48220.0	–3.22	10.27	–1.56
51.00	–62.96	38.88			–42.210	50400	71.25	1.0002	345.58	121.47	0.111		2	16199.0	47726.0	–3.58	11.14	–1.71
54.00	–63.03	38.93			–44.890	50445	71.76	1.0002	346.24	123.68	0.025		0	15789.0	47911.0	–3.95	11.99	–1.86
57.00	–63.04	38.98			–47.560	50518	71.38	0.9995	24.68	160.61	0.147		2	16133.0	47873.0	–4.33	12.86	–2.01
60.00	–63.23	39.04			–50.240	50436	72.03	0.9992	44.07	181.48	0.252		0	15563.0	47975.0	–4.73	13.74	–2.17
63.00	–63.26	39.09			–52.920	50895	71.78	0.9990	51.45	188.13	0.131		0	15910.0	48344.0	–5.14	14.63	–2.33
66.00	–63.45	39.14			–55.600	49484	73.32	0.9992	48.85	190.22	0.062		1	14205.0	47401.0	–5.55	15.50	–2.49
69.00	–63.24	39.19			–58.280	50928	73.40	1.0001	245.21	27.12	0.110		0	14554.0	48804.0	–5.96	16.38	–2.65
72.00	–63.06	39.25			–60.960	51107	66.21	0.9991	118.91	238.25	0.632		2	20618.0	46764.0	–6.39	17.31	–2.83

Bhlen (m)	Dip (degrees)	Magnetic bearing (degrees)	Easting (m)	Northing (m)	Elevation (m)	Mag-field (nT)	Magdip (degrees)	Grav-field	Toolroll (degrees)	Magtool-face (degrees)	Dls (degrees/ m)	Dls 30 (degrees/ 30 m)	Status	Magh (nT)	Magv (nT)	Up-down (m)	Left-right (m)	Shortfall (m)
75.00	–62.99	39.30			–63.630	49631	75.59	1.0002	334.44	122.92	0.250		3	12349.0	48070.0	–6.84	18.26	–3.03
78.00	–62.95	39.30			–66.300	50679	73.33	1.0003	339.05	121.68	0.621		0	14537.0	48549.0	–7.25	19.17	–3.19
81.00	–62.86	39.34			–68.970	50768	73.28	0.9995	216.92	359.56	0.031		0	14604.0	48622.0	–7.62	20.04	–3.35
84.00	–62.84	39.29			–71.640	50796	73.27	1.0001	216.62	359.29	0.011		0	14620.0	48646.0	–7.99	20.91	–3.50
87.00	–62.78	39.41			–74.310	50817	73.27	0.9999	216.99	359.73	0.027		0	14629.0	48666.0	–8.37	21.78	–3.66
90.00	–62.77	39.31			–76.980	50783	73.23	1.0002	218.63	1.28	0.016		0	14657.0	48622.0	–8.74	22.66	–3.81
93.00	–62.79	39.40			–79.650	51016	72.75	1.0001	332.24	114.18	0.459		0	15125.0	48722.0	–9.09	23.50	–3.95
96.00	–62.75	39.49			–82.310	50808	73.48	0.9998	332.53	115.96	0.487		0	14451.0	48709.0	–9.44	24.35	–4.10
99.00	–62.70	39.60			–84.980	51051	73.25	0.9999	344.15	126.82	0.077		0	14715.0	48884.0	–9.81	25.23	–4.25
102.00	–62.60	39.70			–87.650	50766	73.30	0.9996	213.96	357.01	0.035		0	14586.0	48626.0	–10.18	26.12	–4.41
105.00	–62.56	39.81			–90.310	51142	73.09	0.9998	209.91	352.24	0.093		0	14874.0	48932.0	–10.56	27.02	–4.58
108.00	–62.50	39.92			–92.970	50772	73.23	0.9996	211.49	354.56	0.127		0	14649.0	48613.0	–10.93	27.92	–4.74
111.00	–62.48	40.02			–95.630	50992	73.16	0.9999	328.71	111.64	0.023		0	14772.0	48805.0	–11.29	28.81	–4.89
114.00	–62.37	40.13			–98.290	50760	73.28	1.0005	329.28	112.55	0.137		0	14604.0	48614.0	–11.65	29.70	–5.05
117.00	–62.25	40.24			–100.950	50746	73.29	1.0005	328.71	112.38	0.093		0	14589.0	48604.0	–12.01	30.61	–5.22
120.00	–62.19	40.35			–103.600	50746	73.25	1.0002	326.25	109.94	0.040		0	14629.0	48592.0	–12.36	31.51	–5.38
123.00	–62.19	40.45			–106.250	50851	73.31	0.9998	326.84	110.53	0.117		0	14608.0	48708.0	–12.72	32.41	–5.54
126.00	–62.13	40.56			–108.910	50877	73.51	1.0000	327.13	111.28	0.175		0	14440.0	48784.0	–13.08	33.33	–5.71
129.00	–62.06	40.67			–111.560	50810	73.29	1.0000	327.38	111.20	0.148		0	14613.0	48663.0	–13.45	34.26	–5.88
132.00	–62.02	40.77			–114.210	50905	73.45	1.0002	327.12	111.61	0.074		0	14502.0	48795.0	–13.80	35.18	–6.04
135.00	–61.96	40.88			–116.860	50550	73.39	1.0000	327.70	112.46	0.200		0	14453.0	48440.0	–14.14	36.08	–6.20
138.00	–61.89	40.99			–119.500	50782	73.79	1.0005	328.33	112.99	0.946		0	14179.0	48763.0	–14.51	37.02	–6.38
141.00	–61.85	41.09			–122.150	51098	73.11	1.0000	330.50	114.13	0.662		0	14848.0	48893.0	–14.89	37.99	–6.56
144.00	–61.79	41.20			–124.790	50874	73.39	1.0002	332.71	116.42	0.633		0	14544.0	48751.0	–15.27	38.95	–6.75
147.00	–61.70	41.31			–127.440	51515	73.20	0.9999	211.87	355.36	0.159		0	14890.0	49317.0	–15.66	39.95	–6.95
150.00	–61.71	41.41			–130.080	50972	73.31	1.0001	329.57	113.50	0.112		0	14642.0	48824.0	–16.04	40.93	–7.14
153.00	–61.71	41.52			–132.720	50771	73.25	0.9999	318.15	102.33	0.281		0	14630.0	48617.0	–16.41	41.89	–7.32
156.00	–61.64	41.63			–135.360	50756	73.31	1.0004	328.90	113.34	0.027		0	14577.0	48618.0	–16.76	42.83	–7.49
159.00	–61.61	41.74			–138.000	50503	73.25	1.0002	329.16	113.44	0.021		0	14557.0	48360.0	–17.10	43.78	–7.67
162.00	–61.54	41.84			–140.640	50458	73.29	1.0000	335.70	120.21	0.023		0	14512.0	48326.0	–17.45	44.73	–7.84
165.00	–61.51	41.95			–143.280	50697	73.38	0.9996	210.40	355.28	0.024		0	14500.0	48580.0	–17.80	45.67	–8.02
168.00	–61.58	42.06			–145.910	50824	73.45	1.0003	325.68	110.50	0.092		0	14482.0	48717.0	–18.14	46.63	–8.19

Bhlen (m)	Dip (degrees)	Magnetic bearing (degrees)	Easting (m)	Northing (m)	Elevation (m)	Mag-field (nT)	Magdip (degrees)	Grav-field	Toolroll (degrees)	Magtool-face (degrees)	Dls (degrees/ m)	Dls 30 (degrees/ 30 m)	Status	Magh (nT)	Magv (nT)	Up-down (m)	Left-right (m)	Shortfall (m)
171.00	–61.62	42.16			–148.550	51200	73.29	1.0001	330.11	114.02	0.281		0	14722.0	49038.0	–18.51	47.60	–8.38
174.00	–61.54	42.27			–151.190	50736	73.21	0.9998	205.28	349.45	0.260		0	14657.0	48572.0	–18.88	48.57	–8.56
177.00	–61.49	42.38			–153.830	51062	73.74	0.9998	206.02	351.05	0.595		0	14297.0	49020.0	–19.26	49.57	–8.76
180.00	–61.49	42.48			–156.460	50757	73.16	1.0002	208.56	352.66	0.593		0	14707.0	48580.0	–19.64	50.56	–8.96
183.00	–61.54	42.59			–159.100	50811	73.29	1.0001	324.90	109.24	0.037		0	14613.0	48664.0	–19.99	51.53	–9.14
186.00	–61.50	42.70			–161.740	50662	73.34	0.9998	325.28	109.69	0.104		0	14528.0	48534.0	–20.35	52.50	–9.32
189.00	–61.49	42.80			–164.370	50710	73.43	1.0002	325.59	110.17	0.072		0	14466.0	48603.0	–20.72	53.48	–9.51
192.00	–61.46	42.91			–167.010	50782	73.64	1.0000	324.79	110.05	0.012		0	14302.0	48727.0	–21.09	54.46	–9.70
195.00	–61.43	43.02			–169.650	51389	73.40	1.0003	326.59	110.11	1.287		0	14679.0	49248.0	–21.53	55.52	–9.93
198.00	–61.40	43.13			–172.280	52025	73.61	1.0004	329.27	113.16	1.071		1	14682.0	49910.0	–22.08	56.69	–10.22
201.00	–61.32	43.23			–174.920	50978	74.15	0.9998	3.47	149.79	1.891		0	13924.0	49039.0	–22.60	57.83	–10.50
204.00	–61.32	43.34			–177.550	50648	73.18	1.0001	324.72	108.89	0.482		0	14659.0	48480.0	–22.99	58.84	–10.70
207.00	–61.27	43.45			–180.180	51165	73.01	1.0002	325.06	108.31	0.468		0	14951.0	48932.0	–23.37	59.86	–10.90
210.00	–61.25	43.55			–182.810	50695	73.00	1.0000	325.70	109.43	0.438		0	14820.0	48480.0	–23.75	60.88	–11.11
213.00	–61.21	43.66			–185.440	50203	77.14	1.0005	326.58	119.18	2.637		2	11177.0	48943.0	–24.26	62.01	–11.38
216.00	–61.12	43.66			–188.080	50753	73.10	1.0004	327.99	112.16	2.599		0	14754.0	48561.0	–24.77	63.14	–11.65
219.00	–61.07	43.49			–190.700	50937	73.23	1.0003	329.54	114.20	0.033		0	14697.0	48771.0	–25.13	64.14	–11.84
222.00	–61.02	43.30			–193.330	51090	74.54	1.0001	329.75	116.85	1.205		2	13623.0	49241.0	–25.54	65.21	–12.07
225.00	–60.87	43.10			–195.950	51991	75.05	1.0001	332.67	120.73	2.211		2	13409.0	50232.0	–26.15	66.44	–12.40
228.00	–60.66	42.91			–198.570	51414	75.03	1.0001	334.29	122.61	1.303		2	13280.0	49669.0	–26.80	67.72	–12.77
231.00	–60.48	42.72			–201.190	50766	74.34	1.0001	334.44	122.38	1.649		0	13701.0	48882.0	–27.27	68.87	–13.04
234.00	–60.35	42.52			–203.800	51747	74.10	0.9999	335.25	121.78	1.404		0	14174.0	49768.0	–27.73	70.02	–13.31
237.00	–60.21	42.33			–206.400	50150	75.20	1.0001	330.54	120.12	0.394		2	12811.0	48486.0	–28.23	71.23	–13.61
240.00	–60.17	42.14			–209.010	53682	73.70	1.0003	328.70	114.55	2.131		1	15068.0	51524.0	–28.83	72.50	–13.97
243.00	–60.19	41.94			–211.610	52188	74.26	1.0001	328.75	115.68	0.815		1	14156.0	50231.0	–29.51	73.84	–14.37
246.00	–60.16	41.75			–214.210	51830	74.10	1.0001	329.51	116.10	0.202		0	14202.0	49847.0	–30.13	75.13	–14.73
249.00	–60.15	41.75			–216.820	50757	72.99	1.0004	330.75	116.57	2.931		0	14847.0	48537.0	–30.58	76.28	–15.00
252.00	–60.17	41.94			–219.420	50841	73.06	1.0004	336.01	121.93	0.032		0	14817.0	48634.0	–30.87	77.28	–15.19
255.00	–60.14	42.29			–222.030	50923	72.97	1.0000	355.50	141.12	0.059		0	14917.0	48690.0	–31.17	78.29	–15.38
258.00	–60.14	42.72			–224.630	51061	72.96	1.0003	328.27	113.78	0.071		0	14960.0	48820.0	–31.47	79.30	–15.57
261.00	–60.10	42.98			–227.230	50668	73.18	1.0001	328.03	114.14	0.046		0	14661.0	48500.0	–31.78	80.32	–15.76
264.00	–60.06	42.80			–229.830	50927	73.10	1.0003	327.79	113.76	0.032		0	14808.0	48726.0	–32.09	81.35	–15.96

Bhlen (m)	Dip (degrees)	Magnetic bearing (degrees)	Easting (m)	Northing (m)	Elevation (m)	Mag-field (nT)	Magdip (degrees)	Grav-field	Toolroll (degrees)	Magtool-face (degrees)	Dls (degrees/ m)	Dls 30 (degrees/ 30 m)	Status	Magh (nT)	Magv (nT)	Up-down (m)	Left-right (m)	Shortfall (m)
267.00	–60.06	43.01			–232.430	50898	73.13	1.0003	329.17	115.19	0.035		0	14774.0	48707.0	–32.40	82.37	–16.16
270.00	–60.01	43.10			–235.030	50899	73.10	1.0001	331.56	117.55	0.022		0	14798.0	48700.0	–32.70	83.40	–16.36
273.00	–59.95	43.33			–237.620	50918	73.10	1.0001	206.14	352.19	0.043		0	14798.0	48720.0	–33.01	84.43	–16.56
276.00	–59.91	43.42			–240.220	50890	73.24	1.0001	211.76	357.91	0.244		0	14676.0	48728.0	–33.33	85.48	–16.76
279.00	–59.96	43.51			–242.820	50887	73.17	1.0002	326.47	112.64	0.214		0	14732.0	48708.0	–33.65	86.53	–16.97
282.00	–59.91	43.57			–245.410	50879	73.17	1.0002	326.15	112.37	0.019		0	14731.0	48700.0	–33.96	87.57	–17.18
285.00	–59.82	43.58			–248.010	50879	73.11	1.0000	325.00	111.19	0.028		0	14784.0	48684.0	–34.27	88.61	–17.38
288.00	–59.81	43.78			–250.600	50823	73.15	1.0004	324.79	111.06	0.034		0	14734.0	48641.0	–34.58	89.66	–17.59
291.00	–59.75	44.11			–253.190	50823	73.22	1.0001	325.09	111.54	0.058		0	14676.0	48658.0	–34.89	90.71	–17.79
294.00	–59.73	44.12			–255.790	50846	73.25	1.0004	326.55	113.12	0.006		0	14655.0	48688.0	–35.20	91.77	–18.00
297.00	–59.72	44.25			–258.380	50841	73.22	1.0000	328.89	115.37	0.023		0	14681.0	48675.0	–35.52	92.83	–18.21
300.00	–59.68	44.50			–260.970	51070	73.18	1.0004	332.34	118.74	0.044		0	14775.0	48887.0	–35.83	93.89	–18.43
303.00	–59.66	45.14			–263.560	51119	73.34	1.0002	350.17	136.88	0.108		0	14653.0	48974.0	–36.15	94.97	–18.64
306.00	–59.61	44.59			–266.140	50866	73.20	1.0000	209.48	356.00	0.094		0	14703.0	48694.0	–36.47	96.04	–18.86
309.00	–59.59	44.95			–268.730	50843	73.39	0.9999	211.13	358.09	0.061		0	14536.0	48721.0	–36.79	97.11	–19.08
312.00	–59.53	45.06			–271.320	51056	73.11	0.9999	211.90	358.08	0.137		0	14831.0	48854.0	–37.11	98.20	–19.30
315.00	–59.53	45.17			–273.900	50958	73.45	0.9999	212.76	359.60	0.186		0	14517.0	48847.0	–37.45	99.30	–19.53
318.00	–59.48	45.28			–276.490	50929	73.29	1.0000	215.62	2.28	0.150		0	14644.0	48779.0	–37.80	100.41	–19.76
321.00	–59.52	45.38			–279.070	51091	73.28	1.0000	329.31	115.80	0.092		0	14700.0	48930.0	–38.13	101.52	–20.00
324.00	–59.45	45.49			–281.660	50799	73.96	1.0005	330.74	118.66	0.387		0	14040.0	48820.0	–38.49	102.65	–20.24
327.00	–59.38	45.60			–284.240	50808	73.26	1.0006	332.31	119.14	0.584		0	14635.0	48655.0	–38.84	103.77	–20.48
330.00	–59.35	45.71			–286.820	50780	73.27	1.0003	338.14	124.99	0.054		0	14618.0	48630.0	–39.16	104.86	–20.71
333.00	–59.27	45.82			–289.400	50665	73.73	1.0001	206.05	353.68	0.479		0	14196.0	48636.0	–39.51	105.99	–20.95
336.00	–59.23	45.93			–291.980	50851	73.33	1.0001	208.55	355.52	0.307		0	14586.0	48714.0	–39.86	107.13	–21.19
339.00	–59.18	46.03			–294.560	50890	73.20	1.0001	213.88	0.69	0.114		0	14713.0	48717.0	–40.18	108.24	–21.43
342.00	–59.12	46.14			–297.130	51424	73.68	1.0003	215.32	3.63	0.159		0	14447.0	49353.0	–40.50	109.34	–21.65
345.00	–59.03	46.25			–299.710	50747	73.17	1.0000	219.55	6.49	0.157		0	14695.0	48573.0	–40.81	110.45	–21.88
348.00	–59.04	46.36			–302.280	53445	74.05	1.0000	331.46	119.88	0.768		1	14683.0	51388.0	–41.16	111.60	–22.14
351.00	–59.00	46.47			–304.850	51255	73.15	1.0004	328.49	115.36	0.709		0	14861.0	49053.0	–41.52	112.76	–22.39
354.00	–58.98	46.58			–307.420	50806	73.40	1.0007	330.92	118.35	0.088		0	14518.0	48688.0	–41.84	113.89	–22.63
357.00	–58.98	46.69			–309.990	50847	73.33	1.0004	330.08	117.41	0.053		0	14583.0	48711.0	–42.16	115.02	–22.87
360.00	–58.93	46.79			–312.560	50909	73.15	1.0003	329.95	116.94	0.062		0	14756.0	48723.0	–42.48	116.14	–23.11

Bhlen (m)	Dip (degrees)	Magnetic bearing (degrees)	Easting (m)	Northing (m)	Elevation (m)	Mag-field (nT)	Magdip (degrees)	Grav-field	Toolroll (degrees)	Magtool-face (degrees)	Dls (degrees/ m)	Dls 30 (degrees/ 30 m)	Status	Magh (nT)	Magv (nT)	Up-down (m)	Left-right (m)	Shortfall (m)
363.00	–58.92	46.90			–315.130	50827	73.18	1.0005	330.27	117.34	0.009		0	14711.0	48652.0	–42.80	117.27	–23.34
366.00	–58.89	47.01			–317.700	50867	73.20	1.0005	330.54	117.63	0.080		0	14700.0	48697.0	–43.11	118.39	–23.58
369.00	–58.89	47.12			–320.270	50977	73.37	1.0003	331.02	118.40	0.133		0	14589.0	48845.0	–43.44	119.53	–23.83
372.00	–58.83	47.12			–322.840	50883	73.27	1.0005	338.62	125.89	0.063		0	14644.0	48730.0	–43.77	120.68	–24.07
375.00	–58.78	47.38			–325.400	50858	73.33	1.0005	330.81	118.25	0.048		0	14588.0	48721.0	–44.10	121.82	–24.32
378.00	–58.74	47.38			–327.970	50874	73.30	1.0008	345.11	132.52	0.013		0	14616.0	48730.0	–44.43	122.97	–24.57
381.00	–58.73	47.41			–330.530	50906	73.26	1.0002	208.00	355.31	0.007		0	14665.0	48748.0	–44.75	124.12	–24.82
384.00	–58.77	47.30			–333.100	50885	73.29	1.0005	325.79	113.15	0.024		0	14632.0	48736.0	–45.08	125.27	–25.07
387.00	–58.68	47.23			–335.660	50935	73.20	1.0002	330.45	117.71	0.031		0	14719.0	48762.0	–45.41	126.42	–25.31
390.00	–58.63	47.06			–338.220	50795	73.29	1.0004	328.78	116.34	0.034		0	14607.0	48649.0	–45.73	127.57	–25.56
393.00	–58.59	47.18			–340.790	50867	73.41	1.0002	327.85	115.75	0.025		0	14521.0	48750.0	–46.04	128.72	–25.81
396.00	–58.50	47.19			–343.340	50841	73.39	1.0004	338.97	126.93	0.030		0	14534.0	48720.0	–46.36	129.87	–26.06
399.00	–58.42	46.97			–345.900	50864	73.33	1.0004	341.30	129.24	0.047		0	14592.0	48726.0	–46.67	131.03	–26.30
402.00	–58.34	47.19			–348.460	50758	73.50	1.0005	344.06	132.49	0.047		0	14414.0	48669.0	–46.98	132.18	–26.55
405.00	–58.20	47.26			–351.010	50858	73.07	0.9995	205.41	352.94	0.050		0	14813.0	48653.0	–47.28	133.35	–26.80
408.00	–58.12	47.13			–353.560	50736	73.36	1.0002	206.12	354.48	0.034		0	14529.0	48612.0	–47.58	134.51	–27.06
411.00	–58.04	47.01			–356.100	50767	73.38	1.0001	204.17	352.69	0.035		0	14522.0	48645.0	–47.88	135.68	–27.31
414.00	–58.00	46.89			–358.650	51209	73.57	0.9999	203.89	352.64	0.297		0	14481.0	49119.0	–48.19	136.86	–27.57
417.00	–57.96	46.78			–361.190	50367	75.86	0.9997	203.77	356.40	2.500		2	12301.0	48842.0	–48.65	138.17	–27.91
420.00	–57.94	46.66			–363.740	50821	73.33	0.9999	206.07	354.66	2.862		0	14580.0	48685.0	–49.09	139.47	–28.25
423.00	–57.89	46.55			–366.280	50974	73.32	1.0000	206.37	354.92	0.076		0	14633.0	48829.0	–49.38	140.63	–28.50
426.00	–57.87	46.43			–368.820	51035	73.22	1.0002	206.65	355.04	0.061		0	14737.0	48861.0	–49.66	141.80	–28.75
429.00	–57.82	46.32			–371.360	50997	73.65	1.0002	207.44	356.29	0.665		0	14360.0	48934.0	–49.98	143.00	–29.02
432.00	–57.82	46.20			–373.900	50850	73.26	1.0004	207.59	356.19	0.717		0	14651.0	48693.0	–50.29	144.20	–29.29
435.00	–57.79	46.09			–376.440	51403	73.60	1.0001	208.38	357.58	0.231		0	14514.0	49312.0	–50.57	145.38	–29.54
438.00	–57.80	45.97			–378.980	51002	73.37	1.0001	208.76	357.39	0.011		0	14599.0	48868.0	–50.87	146.57	–29.80
441.00	–57.79	45.86			–381.520	51017	73.50	1.0004	211.20	359.69	0.551		0	14490.0	48916.0	–51.19	147.78	–30.08
444.00	–57.75	45.74			–384.060	51088	72.84	1.0003	213.77	1.90	1.187		0	15078.0	48813.0	–51.49	148.97	–30.34
447.00	–57.70	45.63			–386.600	50905	73.38	0.9999	211.00	0.10	0.332		0	14564.0	48777.0	–51.74	150.11	–30.58
450.00	–57.59	45.51			–389.130	50873	73.32	1.0004	210.86	359.98	0.044		0	14602.0	48732.0	–51.99	151.27	–30.82
453.00	–57.63	45.40			–391.660	51060	74.20	1.0005	333.34	123.71	0.771		0	13906.0	49130.0	–52.29	152.47	–31.09
456.00	–57.53	45.28			–394.200	50820	73.22	1.0003	345.64	134.67	0.842		0	14670.0	48656.0	–52.58	153.67	–31.35

Bhlen (m)	Dip (degrees)	Magnetic bearing (degrees)	Easting (m)	Northing (m)	Elevation (m)	Mag-field (nT)	Magdip (degrees)	Grav-field	Toolroll (degrees)	Magtool-face (degrees)	Dls (degrees/ m)	Dls 30 (degrees/ 30 m)	Status	Magh (nT)	Magv (nT)	Up-down (m)	Left-right (m)	Shortfall (m)
459.00	–57.52	45.17			–396.730	50831	73.23	1.0005	345.60	134.70	0.017		0	14664.0	48670.0	–52.83	154.82	–31.59
462.00	–57.47	45.05			–399.260	50809	73.23	1.0007	345.83	134.87	0.087		0	14663.0	48648.0	–53.07	155.98	–31.84
465.00	–57.41	45.05			–401.780	50839	73.27	1.0002	15.19	164.58	0.159		0	14635.0	48687.0	–53.32	157.13	–32.08
468.00	–57.32	45.12			–404.310	50869	73.26	0.9991	108.68	258.14	0.033		0	14653.0	48713.0	–53.55	158.28	–32.32
471.00	–57.21	44.98			–406.830	50878	73.19	1.0002	209.43	358.89	0.046		0	14715.0	48704.0	–53.77	159.44	–32.56
474.00	–57.11	45.03			–409.360	50878	73.22	1.0003	210.15	359.78	0.032		0	14687.0	48712.0	–54.00	160.59	–32.80
477.00	–57.07	44.97			–411.870	50880	73.21	0.9996	210.75	0.43	0.018		0	14695.0	48712.0	–54.21	161.75	–33.04
480.00	–57.04	45.00			–414.390	50868	73.22	1.0000	210.41	0.14	0.012		0	14684.0	48702.0	–54.43	162.91	–33.28
483.00	–57.01	44.98			–416.910	50865	73.19	1.0003	211.07	0.75	0.011		0	14714.0	48691.0	–54.65	164.07	–33.52
486.00	–56.90	45.07			–419.420	50855	73.22	1.0000	211.29	1.15	0.038		0	14681.0	48690.0	–54.86	165.23	–33.77
489.00	–56.85	45.08			–421.940	50863	73.21	1.0001	210.88	0.76	0.016		0	14695.0	48694.0	–55.07	166.40	–34.01
492.00	–56.79	45.04			–424.450	50861	73.22	1.0002	212.83	2.81	0.022		0	14688.0	48694.0	–55.28	167.56	–34.25
495.00	–56.68	44.86			–426.950	50863	73.17	1.0006	213.99	4.04	0.051		0	14723.0	48686.0	–55.48	168.73	–34.50
498.00	–56.66	44.98			–429.460	50965	73.06	1.0000	214.64	4.59	0.116		0	14852.0	48753.0	–55.68	169.89	–34.74
501.00	–56.64	45.10			–431.970	50890	73.20	1.0002	225.23	15.31	0.160		0	14712.0	48717.0	–55.87	171.06	–34.98
504.00	–56.55	44.88			–434.470	50882	73.17	1.0002	213.60	3.78	0.050		0	14730.0	48703.0	–56.07	172.23	–35.23
507.00	–56.59	44.72			–436.980	50875	73.26	0.9998	28.98	179.35	0.032		0	14655.0	48718.0	–56.26	173.40	–35.47
510.00	–56.54	44.65			–439.480	50871	73.26	0.9996	43.81	194.25	0.021		0	14654.0	48715.0	–56.46	174.57	–35.71
513.00	–56.48	44.65			–441.980	50841	73.23	0.9997	44.06	194.50	0.020		0	14672.0	48678.0	–56.65	175.74	–35.96
516.00	–56.37	44.90			–444.480	50877	73.22	0.9999	208.86	359.34	0.058		0	14691.0	48710.0	–56.83	176.91	–36.20
519.00	–56.30	44.86			–446.980	50910	73.09	1.0000	209.42	359.70	0.025		0	14805.0	48709.0	–57.02	178.09	–36.45
522.00	–56.27	44.65			–449.470	50852	73.22	1.0002	14.84	165.49	0.040		0	14683.0	48686.0	–57.20	179.26	–36.70
525.00	–56.19	44.86			–451.970	51010	73.09	1.0003	209.42	359.82	0.049		0	14836.0	48805.0	–57.38	180.44	–36.94
528.00	–56.17	44.61			–454.460	50845	73.23	1.0004	345.46	136.24	0.047		0	14673.0	48682.0	–57.56	181.62	–37.19
531.00	–56.13	44.49			–456.950	50866	73.21	1.0007	330.41	121.23	0.027		0	14695.0	48697.0	–57.73	182.80	–37.44
534.00	–56.06	44.41			–459.440	50867	73.21	1.0006	347.85	138.77	0.027		0	14693.0	48699.0	–57.90	183.98	–37.68
537.00	–56.00	44.43			–461.930	50857	73.21	1.0003	348.66	139.63	0.019		0	14692.0	48689.0	–58.06	185.16	–37.93
540.00	–55.93	44.21			–464.410	50866	73.22	1.0002	13.56	164.68	0.048		0	14689.0	48699.0	–58.22	186.34	–38.18
543.00	–55.85	44.20			–466.900	50872	73.25	0.9994	40.02	191.29	0.027		0	14664.0	48713.0	–58.38	187.51	–38.42
546.00	–55.69	44.46			–469.380	50869	73.15	1.0004	212.50	3.66	0.072		0	14743.0	48686.0	–58.53	188.70	–38.67
549.00	–55.63	44.37			–471.860	50871	73.18	1.0001	207.15	358.45	0.026		0	14722.0	48694.0	–58.68	189.89	–38.92
552.00	–55.55	44.34			–474.330	50877	73.19	1.0001	211.30	2.72	0.026		0	14713.0	48703.0	–58.82	191.08	–39.17

Bhlen (m)	Dip (degrees)	Magnetic bearing (degrees)	Easting (m)	Northing (m)	Elevation (m)	Mag-field (nT)	Magdip (degrees)	Grav-field	Toolroll (degrees)	Magtool-face (degrees)	Dls (degrees/ m)	Dls 30 (degrees/ 30 m)	Status	Magh (nT)	Magv (nT)	Up-down (m)	Left-right (m)	Shortfall (m)
555.00	–55.45	44.34			–476.800	50876	73.17	1.0002	212.22	3.69	0.034		0	14733.0	48696.0	–58.97	192.27	–39.42
558.00	–55.37	44.28			–479.270	50879	73.17	1.0003	209.53	1.10	0.028		0	14730.0	48700.0	–59.10	193.47	–39.67
561.00	–55.30	44.23			–481.740	50881	73.17	1.0005	210.63	2.30	0.027		0	14729.0	48702.0	–59.24	194.66	–39.92
564.00	–55.22	44.12			–484.210	50876	73.16	1.0003	209.88	1.63	0.034		0	14735.0	48695.0	–59.36	195.86	–40.18
567.00	–55.14	44.06			–486.670	50876	73.18	1.0003	210.40	2.29	0.029		0	14718.0	48700.0	–59.49	197.06	–40.43
570.00	–55.01	43.95			–489.130	50874	73.18	1.0004	214.72	6.76	0.045		0	14719.0	48698.0	–59.61	198.26	–40.68
573.00	–54.87	43.77			–491.580	50872	73.18	1.0003	215.86	8.06	0.058		0	14724.0	48694.0	–59.72	199.46	–40.93
576.00	–54.76	43.71			–494.040	50881	73.17	1.0003	215.11	7.44	0.040		0	14728.0	48703.0	–59.82	200.66	–41.19
579.00	–54.67	43.62			–496.480	50870	73.19	1.0003	216.06	8.52	0.033		0	14715.0	48696.0	–59.91	201.86	–41.44
582.00	–54.61	43.54			–498.930	50881	73.16	1.0002	211.52	4.00	0.026		0	14742.0	48698.0	–60.01	203.06	–41.69
585.00	–54.51	43.57			–501.380	50878	73.18	1.0003	212.64	5.25	0.035		0	14725.0	48700.0	–60.10	204.26	–41.95
588.00	–54.40	43.54			–503.820	50882	73.18	1.0001	212.68	5.41	0.036		0	14722.0	48706.0	–60.18	205.47	–42.20
591.00	–54.33	43.55			–506.250	50881	73.16	1.0002	212.10	4.85	0.025		0	14740.0	48699.0	–60.26	206.68	–42.46
594.00	–54.26	43.55			–508.690	50889	73.14	1.0004	213.69	6.47	0.021		0	14757.0	48702.0	–60.34	207.89	–42.71
597.00	–54.27	43.48			–511.130	50874	73.16	1.0003	215.00	7.82	0.014		0	14737.0	48693.0	–60.41	209.10	–42.97
600.00	–54.29	43.20			–513.560	50860	73.19	1.0005	349.24	142.19	0.055		0	14706.0	48688.0	–60.48	210.31	–43.22
603.00	–54.29	43.31			–516.000	50886	73.22	0.9990	105.90	258.88	0.021		0	14690.0	48720.0	–60.56	211.52	–43.48
606.00	–54.24	43.21			–518.430	50886	73.23	0.9987	107.15	260.21	0.024		0	14686.0	48720.0	–60.63	212.72	–43.73
609.00	–54.19	43.16			–520.870	50885	73.22	0.9990	108.61	261.72	0.019		0	14688.0	48719.0	–60.69	213.93	–43.99
612.00	–54.18	43.15			–523.300	50889	73.23	0.9990	108.66	261.81	0.004		0	14680.0	48725.0	–60.76	215.14	–44.24
615.00	–54.10	43.04			–525.730	50883	73.24	0.9991	108.03	261.30	0.035		0	14672.0	48722.0	–60.82	216.34	–44.49
618.00	–54.04	43.03			–528.160	50891	73.23	0.9993	108.77	262.07	0.020		0	14683.0	48726.0	–60.88	217.55	–44.75
621.00	–54.08	43.09			–530.590	50892	73.24	0.9993	108.98	262.26	0.017		0	14675.0	48730.0	–60.94	218.76	–45.00
624.00	–54.07	42.98			–533.020	50891	73.27	0.9991	108.26	261.62	0.022		0	14653.0	48736.0	–61.00	219.96	–45.26
627.00	–54.01	43.00			–535.450	50903	73.26	0.9992	109.09	262.49	0.021		0	14662.0	48745.0	–61.05	221.17	–45.51
630.00	–53.96	42.87			–537.870	50883	73.27	0.9987	108.74	262.24	0.031		0	14649.0	48729.0	–61.10	222.38	–45.76
633.00	–53.84	42.74			–540.300	50888	73.24	0.9989	109.55	263.12	0.047		0	14678.0	48725.0	–61.15	223.59	–46.02
636.00	–53.77	42.71			–542.720	50903	73.26	0.9990	109.80	263.49	0.023		0	14663.0	48745.0	–61.19	224.79	–46.27
639.00	–53.75	42.69			–545.140	50886	73.25	0.9990	109.22	262.92	0.008		0	14664.0	48727.0	–61.23	226.00	–46.53
642.00	–53.71	42.56			–547.560	50882	73.26	0.9991	109.19	262.99	0.029		0	14654.0	48726.0	–61.27	227.21	–46.78
645.00	–53.64	42.53			–549.970	50883	73.27	0.9991	109.08	262.97	0.025		0	14647.0	48729.0	–61.30	228.42	–47.03
648.00	–53.55	42.28			–552.390	50891	73.26	0.9995	109.46	263.47	0.056		0	14655.0	48736.0	–61.33	229.62	–47.29

Bhlen (m)	Dip (degrees)	Magnetic bearing (degrees)	Easting (m)	Northing (m)	Elevation (m)	Mag-field (nT)	Magdip (degrees)	Grav-field	Toolroll (degrees)	Magtool-face (degrees)	Dls (degrees/ m)	Dls 30 (degrees/ 30 m)	Status	Magh (nT)	Magv (nT)	Up-down (m)	Left-right (m)	Shortfall (m)
651.00	–53.48	42.14			–554.800	50904	73.22	0.9992	109.90	263.93	0.038		0	14700.0	48735.0	–61.35	230.83	–47.54
654.00	–53.44	42.00			–557.210	50917	73.23	0.9989	109.99	264.11	0.030		0	14695.0	48750.0	–61.36	232.03	–47.79
657.00	–53.41	41.98			–559.620	50901	73.20	0.9991	110.47	264.56	0.011		0	14716.0	48728.0	–61.37	233.23	–48.04
660.00	–53.40	41.89			–562.030	50933	73.21	0.9991	109.26	263.42	0.018		0	14710.0	48762.0	–61.38	234.43	–48.29
663.00	–53.37	41.63			–564.440	50913	73.28	0.9993	110.25	264.65	0.052		0	14645.0	48762.0	–61.39	235.63	–48.54
666.00	–53.33	41.80			–566.840	50915	73.23	0.9994	110.46	264.76	0.037		0	14688.0	48750.0	–61.39	236.83	–48.79
669.00	–53.32	41.78			–569.250	50915	73.24	0.9995	109.94	264.26	0.004		0	14681.0	48752.0	–61.40	238.03	–49.04
672.00	–53.28	41.76			–571.650	50925	73.22	0.9993	109.24	263.55	0.016		0	14705.0	48756.0	–61.40	239.23	–49.29
675.00	–53.27	41.88			–574.060	50912	73.28	0.9992	109.64	264.04	0.024		0	14651.0	48759.0	–61.40	240.43	–49.55
678.00	–53.22	41.73			–576.460	50954	73.31	0.9990	109.20	263.76	0.033		0	14636.0	48807.0	–61.40	241.63	–49.80
681.00	–53.24	41.71			–578.860	50870	73.23	0.9993	109.17	263.56	0.006		0	14675.0	48708.0	–61.40	242.83	–50.05
684.00	–53.23	41.71			–581.270	50920	73.23	0.9990	111.18	265.59	0.003		0	14688.0	48756.0	–61.40	244.03	–50.30
687.00	–53.21	41.69			–583.670	50925	73.23	0.9991	110.47	264.90	0.007		0	14691.0	48760.0	–61.40	245.23	–50.55
690.00	–53.18	41.70			–586.070	50890	73.26	0.9988	110.28	264.77	0.010		0	14661.0	48732.0	–61.39	246.44	–50.80
693.00	–53.17	41.66			–588.470	50922	73.20	0.9994	110.91	265.32	0.010		0	14716.0	48749.0	–61.39	247.64	–51.05
696.00	–53.15	41.62			–590.880	50937	73.20	0.9994	109.75	264.17	0.010		0	14726.0	48762.0	–61.38	248.84	–51.30
699.00	–53.14	41.69			–593.280	50943	73.22	0.9987	112.86	267.32	0.014		0	14708.0	48773.0	–61.38	250.04	–51.55
702.00	–53.16	41.58			–595.680	50942	73.21	0.9994	110.12	264.57	0.023		0	14714.0	48771.0	–61.37	251.24	–51.80
705.00	–53.13	41.58			–598.080	50917	73.18	0.9989	110.66	265.08	0.012		0	14731.0	48739.0	–61.36	252.44	–52.06
708.00	–53.04	41.70			–600.480	50928	73.20	0.9993	109.80	264.30	0.037		0	14717.0	48755.0	–61.36	253.64	–52.31
711.00	–53.01	41.66			–602.870	50895	73.19	0.9990	111.36	265.89	0.015		0	14716.0	48721.0	–61.34	254.85	–52.56
714.00	–52.97	41.66			–605.270	50930	73.20	0.9990	108.58	263.16	0.011		0	14721.0	48756.0	–61.33	256.06	–52.81
717.00	–52.91	41.54			–607.660	50926	73.19	0.9996	109.75	264.39	0.032		0	14726.0	48750.0	–61.32	257.26	–53.07
720.00	–52.89	41.51			–610.050	50895	73.18	0.9993	110.26	264.90	0.010		0	14729.0	48717.0	–61.30	258.47	–53.32
723.00	–52.85	41.55			–612.450	50891	73.19	0.9990	110.48	265.17	0.016		0	14720.0	48716.0	–61.28	259.67	–53.57
726.00	–52.75	41.42			–614.840	50913	73.09	0.9991	110.20	264.81	0.041		0	14812.0	48711.0	–61.25	260.88	–53.83
729.00	–52.75	41.53			–617.220	50910	73.07	0.9992	109.08	263.63	0.022		0	14822.0	48705.0	–61.23	262.09	–54.08
732.00	–52.68	41.83			–619.610	50762	73.26	0.9991	109.85	264.73	0.065		0	14626.0	48610.0	–61.20	263.31	–54.34
735.00	–52.63	41.63			–622.000	50911	73.24	0.9993	112.45	267.40	0.044		0	14682.0	48748.0	–61.18	264.52	–54.60
738.00	–52.61	41.37			–624.380	50876	73.18	0.9993	109.39	264.32	0.053		0	14719.0	48701.0	–61.15	265.74	–54.85
741.00	–52.58	41.47			–626.760	50884	73.31	0.9992	111.05	266.22	0.022		0	14614.0	48740.0	–61.11	266.95	–55.11
744.00	–52.58	41.58			–629.150	50736	73.38	0.9994	109.80	265.09	0.022		0	14510.0	48617.0	–61.08	268.16	–55.37

Bhlen (m)	Dip (degrees)	Magnetic bearing (degrees)	Easting (m)	Northing (m)	Elevation (m)	Mag-field (nT)	Magdip (degrees)	Grav-field	Toolroll (degrees)	Magtool-face (degrees)	Dls (degrees/ m)	Dls 30 (degrees/ 30 m)	Status	Magh (nT)	Magv (nT)	Up-down (m)	Left-right (m)	Shortfall (m)
747.00	–52.54	41.51			–631.530	50757	73.15	0.9991	110.56	265.44	0.019		0	14715.0	48577.0	–61.05	269.38	–55.62
750.00	–52.51	41.43			–633.910	51181	73.26	0.9990	110.12	265.28	0.019		0	14740.0	49012.0	–61.01	270.59	–55.88
753.00	–52.49	41.40			–636.290	50837	73.48	0.9992	107.67	263.40	0.096		0	14457.0	48738.0	–60.97	271.80	–56.13
756.00	–52.39	41.37			–638.670	50663	73.30	1.0006	230.31	25.94	0.115		0	14557.0	48526.0	–60.91	273.00	–56.38
759.00	–52.32	41.35			–641.040	50857	73.28	1.0009	230.26	25.59	0.209		0	14636.0	48706.0	–60.86	274.21	–56.64
762.00	–52.30	41.32			–643.420	50880	73.48	1.0007	229.49	24.95	0.212		0	14464.0	48781.0	–60.82	275.44	–56.90
765.00	–52.28	41.29			–645.790	50876	73.23	1.0003	232.78	28.03	0.194		0	14678.0	48713.0	–60.79	276.67	–57.17
768.00	–52.27	41.26			–648.160	50871	73.16	1.0004	230.70	25.88	0.039		0	14739.0	48689.0	–60.74	277.89	–57.43
771.00	–52.26	41.23			–650.530	50847	72.72	1.0008	231.15	25.99	0.343		0	15101.0	48553.0	–60.68	279.09	–57.68
774.00	–52.25	41.21			–652.910	50697	73.54	1.0008	229.75	25.39	0.547		0	14367.0	48619.0	–60.62	280.30	–57.94
777.00	–52.21	41.18			–655.280	50768	73.10	1.0008	232.36	27.32	0.111		0	14763.0	48574.0	–60.58	281.54	–58.20
780.00	–52.20	41.15			–657.650	50767	73.31	1.0006	232.36	27.84	0.057		0	14580.0	48629.0	–60.54	282.77	–58.47
783.00	–52.09	41.15			–660.020	50982	73.15	1.0005	230.89	26.25	0.083		0	14775.0	48794.0	–60.48	283.99	–58.73
786.00	–52.03	41.12			–662.380	50945	73.21	1.0010	235.52	31.05	0.021		0	14719.0	48773.0	–60.42	285.21	–58.99
789.00	–51.97	41.12			–664.750	50947	73.15	1.0005	233.39	28.87	0.023		0	14766.0	48761.0	–60.36	286.43	–59.25
792.00	–51.92	41.19			–667.110	50950	73.15	1.0007	234.73	30.22	0.022		0	14768.0	48763.0	–60.29	287.65	–59.51
795.00	–51.88	41.19			–669.470	50953	73.17	1.0008	233.23	28.77	0.011		0	14756.0	48770.0	–60.22	288.88	–59.77
798.00	–51.86	41.20			–671.830	50944	73.17	1.0007	232.75	28.31	0.009		0	14754.0	48760.0	–60.15	290.10	–60.03
801.00	–51.83	41.06			–674.190	50991	73.18	1.0005	234.24	29.90	0.030		0	14752.0	48811.0	–60.08	291.33	–60.30
804.00	–51.82	41.14			–676.550	50905	73.24	1.0009	247.17	42.92	0.017		0	14680.0	48742.0	–60.01	292.55	–60.56
807.00	–51.76	41.12			–678.900	50931	73.18	1.0007	236.22	31.92	0.022		0	14737.0	48752.0	–59.93	293.78	–60.82
810.00	–51.74	41.17			–681.260	50932	73.19	1.0005	237.79	33.50	0.012		0	14732.0	48754.0	–59.86	295.01	–61.09
813.00	–51.71	41.03			–683.620	50951	73.17	1.0003	235.31	31.03	0.031		0	14757.0	48768.0	–59.78	296.24	–61.35
816.00	–51.68	41.06			–685.970	50945	73.19	1.0006	238.31	34.11	0.011		0	14730.0	48769.0	–59.70	297.46	–61.61
819.00	–51.66	40.99			–688.320	50986	73.12	1.0009	237.51	33.21	0.017		0	14805.0	48789.0	–59.62	298.69	–61.88
822.00	–51.61	41.34			–690.680	50997	73.17	1.0004	234.08	29.81	0.074		0	14762.0	48813.0	–59.54	299.92	–62.14
825.00	–51.59	41.34			–693.030	50931	73.10	1.0003	237.98	33.60	0.009		0	14804.0	48732.0	–59.47	301.16	–62.41
828.00	–51.57	41.70			–695.380	50836	73.32	1.0004	238.54	34.47	0.075		0	14594.0	48696.0	–59.39	302.40	–62.68
831.00	–51.54	41.15			–697.730	51007	73.21	1.0007	234.85	30.77	0.114		0	14732.0	48833.0	–59.31	303.64	–62.95
834.00	–51.53	41.46			–700.080	50845	72.94	0.9991	136.06	291.37	0.064		0	14918.0	48607.0	–59.23	304.88	–63.22
837.00	–51.48	41.67			–702.420	50939	72.98	0.9992	123.27	278.62	0.046		0	14914.0	48706.0	–59.15	306.12	–63.49
840.00	–51.43	41.37			–704.770	50838	72.96	0.9992	116.96	272.42	0.065		0	14896.0	48606.0	–59.07	307.37	–63.76

Appendix 4

Length reference marks

Reference mark T – Reference mark in drillhole

KFM11A, 2006-10-25 09:00:00 – 2006-10-31 18:00:00 (100.000–801.000 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)	Comment
100.00	400.00	400	300	30.0	115	Ja		[Mäthjulet ställdes på 100.0 m]
149.20	400.00	400	300	30.0	128	Ja		Fräsen tappades; [149.47/149.57]
200.00	400.00	200	1000	30.0	120	Ja		Ny spårfräs; [200.53/200.63]
250.00	400.00	200	1000	30.0	84	Ja		Wirelängd : [250.72/250.82]
300.00	400.00	300	1000	30.0	74	Ja		[301.05/301.15]
350.00	400.00	300	1000	30.0	77	Ja		[351.20/351.30]
400.00	400.00	300	1000	30.0	70	Ja		[401.42/401.52]
449.00	400.00	300	1000	30.0	75	Ja		[450.72/450.82]
497.00	400.00	300	1000	30.0	68	Ja		[498.98/499.08]
550.00	400.00	300	1000	30.0	96	Ja		[552.18/552.28]
603.00	400.00	300	1000	30.0	78	Ja		[605.40/605.50]
648.00	400.00	300	1000	30.0	76	Ja		[650.67/650.77]
700.00	400.00	400	1000	30.0	99	Ja		[702.85/702.95]
750.00	400.00	400	1000	30.0	99	Ja		[753.16/403.26]
801.00								Avbrutet på grund av fel i fräsen. Upptag.

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