P-13-28

Äspö Hard Rock Laboratory

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July 2013

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ISSN 1651-4416
SKB P-13-28
ID 1385931

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Keywords: KA3011A01, KA3065A01 geology, Drill core mapping, Boremap, Fractures, BIPS, Äspö HRL, Äspö SDM.

Abstract

This report presents the Boremap mapping of KA3011A01, which is a c 100 m long core drilled borehole and KA3065A01, which is a c 125 m long core drilled borehole. The borehole KA3011A01 was drilled with the orientation 055°/–1.2° and the borehole KA3065A01 was drilled with the orientation 055°/–0.6°. The borehole orientations are related to Äspö96. The mapping of KA3011A01 was conducted between 2011-11-28 and 2011-12-01 and KA3065A01 between 2012-01-17 and 2012-01-20.

The documentation of geological structures and lithology intersecting boreholes KA3011A01 and KA3065A01 were made using the drill core and BIPS-images. Geological structures are correctly oriented in space along the borehole with the Boremap system. All orientations are related to Äspö96.

The lithology in KA3011A01 is dominated by Ävrö granodiorite (501056). In the lower half of the borehole the Ävrö granodiorite (501056) is intermingled with Äspö diorite (501037). A section with fine-grained granite (511058) occurs in the upper part of the borehole. Subordinate rock types comprise occurrences of pegmatite (501061) and fine-grained diorite-gabbro (505102).

One section in KA3011A01 has been highlighted based on increased fracture frequencies, alterations and structural features. This section covers the interval 14–35 m.

The lithology in KA3065A01 is dominated by Äspö diorite (501037). Two sections with Ävrö granodiorite (501056) occurs in the upper part of the borehole, separated by a section with fine-grained diorite-gabbro (505102). A section with fine-grained granite (511058) occurs in the lower half of the borehole. Subordinate rock types comprise occurrences of pegmatite (501061) and sparse occurrences of breccia (508002) and mylonite (508004).

Sammanfattning

Denna rapport presenterar boremapkartering av KA3011A01 som är ett ca 100 meter långt kärnborrhål och KA3065A01 som är ett ca 125 meter långt kärnborrhål. Borrhål KA3011A01 borrades med orienteringen 055°/–1.2° och borrhål KA3065A01 med orienteringen 055°/–0.6°. Borrhålens orienteringar är relaterade till Äspö96. Boremapkartering för KA3011A01 utfördes mellan 2011-11-28 och 2011-12-01 och för KA3065A01 mellan 2012-01-17 och 2012-01-20.

Dokumentationen av geologiska strukturer och litologi som genomskär borrhålen KA3011A01 och KA3065A01 har utförts med borrkärna och BIPS-bilder. Geologiska strukturer har orienterats i rummet längs med borrhålet med Boremap systemet. Alla orienteringar är relaterade till Äspö96.

KA3011A01 domineras av Ävrögranodiorit (501056). I nedre delen av borrhålet är Ävrögranodiorit uppblandad med Äspödiorit (501037). En sektion med finkornig granit (511058) återfinns i borrhålets översta del. Underordnade bergarter utgörs av pegmatit (501061) och finkornig diorit-gabbro (505102).

En sektion i KA3011A01 kan urskiljas baserat på förhöjd sprickfrekvens, bergets omvandlingar och geologiska strukturer. Denna sektion återfinns i intervallet 14–35 m.

KA3065A01 domineras av Äspödiorit (501037). Två sektioner med Ävrögranodiorit (501056) förekommer i översta delen av borrhålet, åtskilda sinsemellan av en sektion med finkorning diorit-gabbro (505102). En sektion med finkornig granit (511058) återfinns i borrhålets nedre del. Underordnade bergarter utgörs av pegmatit (501061) och mindre delar med breccia (508002) och mylonit (508004).

Contents

1 Introduction

This report gives a brief presentation of the data gained from the mapping of boreholes KA3011A01 and KA3065A01, which is a part of the project TUDP002 "Expansion of Äspö HRL 2011–2012". After completion both boreholes were BIPS-logged and mapped according to the Boremap method. This document reports data gained by the Boremap mapping. The work was carried out in accordance with activity plan AP TD TUDP002-11-87. Controlling documents for performing this activity are listed in Table 1-1. Both activity plan and method descriptions are SKB's internal controlling documents. Rock type nomenclature that has been used is shown in Table 1-2.

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

Activity plan	Number	Version
Äspö utbyggnad, DP1-Karaktärisering – Boremapkartering av KA3011A01 och KA3065A01	AP TD TUDP002-11-87	1.0
Method descriptions	**Number**	**Version**
Nomenklatur vid Boremapkartering	SKB MD 143.008	1.0
Method Description for Boremap mapping	SKB MD 143.006	3.0
Mätsystembeskrivning för Boremap	SKB MD 146.005	1.0
Instruktion: Regler för bergarters benämningar vid plats-undersökning I Oskarshamn	SKB MD 132.004	3.0
Instruktion för längdkalibrering vid undersökningar i kärnborrhål	SKB MD 620.010	2.0

Table 1-2. Rock type nomenclature for the investigation at the Äspö Site Descriptive Model.

Rock type	Rock code	Rock Description
Dolerite	501027	Dolerite
Fine-grained Götemar granite	531058	Granite, fine- to medium-grained, ("Götemar granite")
Coarse-grained Götemar granite	521058	Granite, coarse-grained, ("Götemar granite")
Fine-grained granite	511058	Granite, fine- to medium-grained
Pegmatite	501061	Pegmatite
Granite	501058	Granite, medium- to coarse-grained
Ävrö granite	501044	Granite to quartz monzodiorite, generally porphyritic
Ävrö granodiorite	501056	Granite to granodiorite, sparsely porphyritic to porphyritic
Ävrö quartz monzodiorite	501046	Quartz monzonite to quartz monzodiorite, generally porphyritic
Äspö diorite	501037	Quartz monzodiorite to granodiorite, porphyritic
Quartz monzodiorite	501036	Quartz monzonite to monzodiorite, equigranular to weakly porphyritic
Diorite-gabbro	501033	Diorite to gabbro
Fine-grained dioritoid	501030	Intermediate magmatic rock
Fine-grained diorite-gabbro	505102	Mafic rock, fine-grained
Gabbroid-dioritoid	508107	Mafic rock undifferentiated
Mylonite	508004	Mylonite
Sulphide mineralization	509010	Sulphide mineralization
Sandstone	506007	Sandstone
Quartz-dominated hydrothermal vein/segregation	508021	Quartz-dominated hydrothermal vein/segregation
Hybrid rock	505105	Hybrid rock
Breccia	508002	Breccia
Felsic volcanic rock	503076	Felsic volcanic rock

Boreholes KA3011A01 and KA3065A01 are situated in the Äspö Hard Rock Laboratory (Figure 1-1). KA3011A01 is a c 100 m long borehole drilled from the tunnel with the orientation 055°/–1.2° at the start. Mapping of the borehole was performed between 2011-11-28 and 2011-12-01. KA3065A01 is a c 125 m long borehole drilled from the tunnel with the orientation 055°/–0.6° at the start. Mapping of the borehole was performed between 2012-01-17 and 2012-01-20.

Detailed mapping of the drill cores is essential for a three dimensional modelling of the geology outside the tunnel. The mapping is based on the use of BIPS-image (Borehole Image Processing System) of the borehole wall and by the study of the drill core itself. The BIPS-image enables the study of orientations, since the Boremap software calculates strike and dip of planar features such as foliations, rock contacts and fractures.

All data were stored in the primary SKB database Sicada (Site Characterisation Database) and are traceable by the activity plan number.

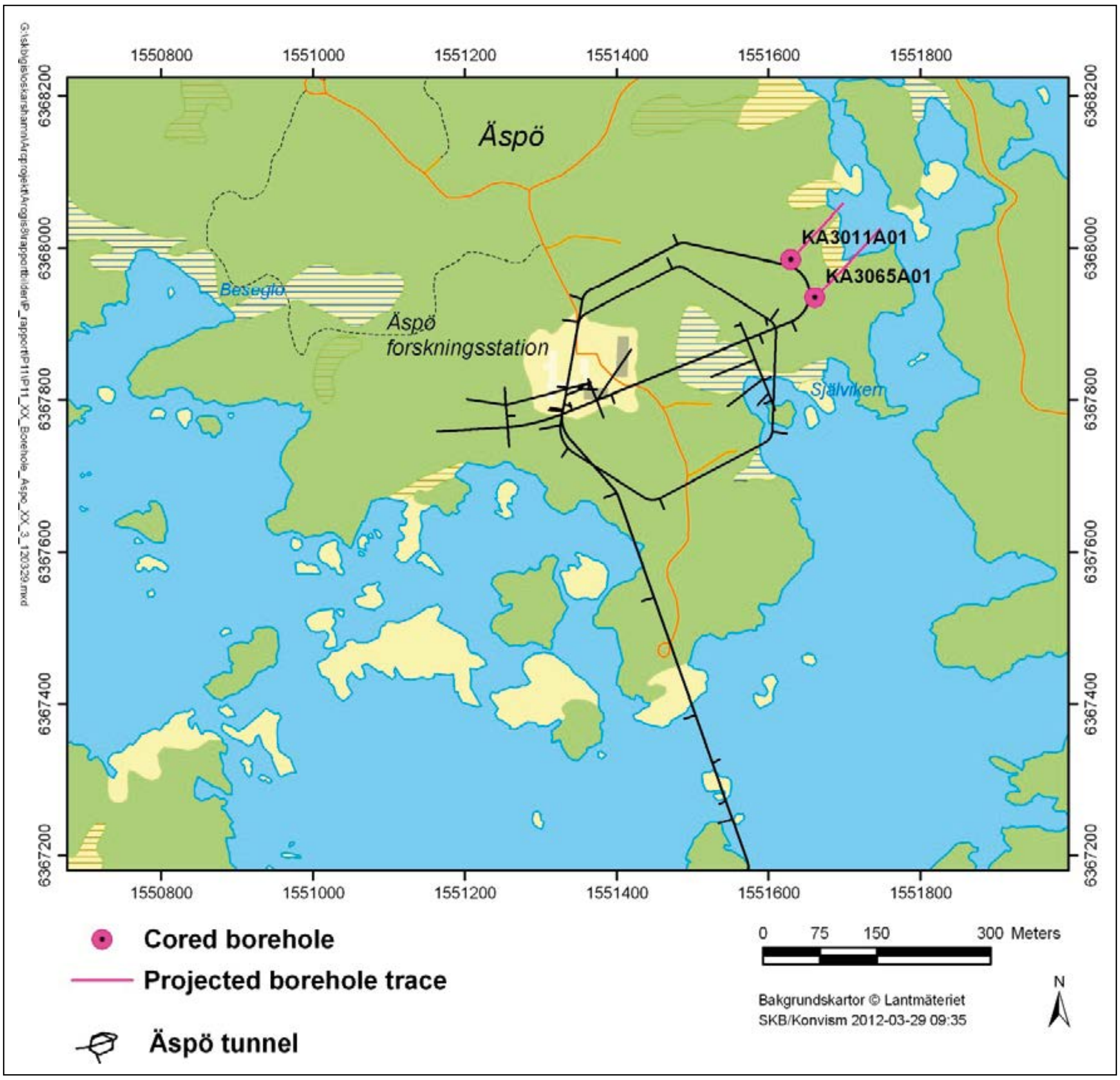


Figure 1-1. Map showing the position of the cored boreholes KA3011A01 and KA3065A01.

2 Objective and scope

The principal aim of the mapping activities presented in this report is to obtain a documentation of geological structures and lithologies intersecting boreholes KA3011A01 and KA3065A01. Geological structures will be correctly orientated in space along the borehole with the Boremap system. All orientations are related to Äspö96.

3 Equipment

3.1 Description of Software

Software used for the mapping of KA3011A01 and KA3065A01 was Boremap v. 4.1.5.0 with bedrock and mineral standards of SKB. The data presentation was made using WellCAD v. 4, Microsoft Access and Microsoft Excel. Boremap is the software that unites orthodox core mapping with modern video mapping, where Boremap shows the image from BIPS (Borehole Image Processing System) and extracts the geometrical parameters: length, width, strike and dip from the image.

3.2 Other equipment

The following equipment is used to facilitate the core mapping: folding rule, pen, diluted hydrochloric acid, knife, water-filled atomiser and hand lens.

3.3 BIPS-image video film sequences

The BIPS-image of KA3011A01 covers the interval 1.852–99.900 m, and for KA3065A01 it covers the interval 1.992–125.000 m.

3.4 BIPS-image video film quality

The quality of the BIPS-image depends on several parameters

- The clarity of the borehole water (i.e. the amount of material in suspension).
- The condition of the borehole walls (e.g. the amount of sedimentation and/or gauge on the borehole wall).
- The quality of the BIPS-image (i.e. the technical limitations of the image; resolution and contrast).

3.4.1 BIPS-image resolution

Resolution of the BIPS-image is perhaps the principal reason why very thin fractures as well as very thin apertures are not visible in the BIPS-image and the resolution depends on the BIPS video camera pixel size and illumination angle.

3.4.2 BIPS-image contrast

Thick fractures are always visible in both drill core and the BIPS-image. However, the visibility of thin fractures depends strongly on the contrast between the fracture and the wall rock. A bright fracture in a dark rock is clearly visible in the BIPS-image. But a bright coloured fracture in a light coloured rock might, however, be clearly visible in the drill core but not visible in the BIPS-image, especially if the fracture and wall rock have the same colour. The opposite is true for dark fractures.

In very rare cases when the BIPS-image contrast between a very thin fracture and the wall rock is very strong the fracture might be visible in the BIPS-image even if it is not visible in the drill core.

3.4.3 BIPS-image quality

BIPS-image quality is sometimes limited due to:

1) blackish coatings probably related to the drilling equipment.
2) vertical bleached bands from the clayey mixture of drill cuttings and water.
3) light and dark bands at high angle to the drill hole related to the automatic aperture of the video camera.
4) vertical enlargements of pixels due to stick-slip movement of the camera probe.

Vertical bleached bands are usually the main disturbances in the BIPS-image quality.

The image quality is classified into four levels; good, acceptable, bad and very bad. Good quality means a more or less clear image which is easy to interpret. If the quality is acceptable it means that the image is not good, but that the mapping can be performed without any problems. An image of bad quality is somewhat difficult to interpret while an image of very bad quality cannot be interpreted except from very obvious and outstanding features. When the BIPS-image quality is so bad that fractures and structures cannot be identified, they can still be oriented using the *guide-line method* (Section 4.3.3). The BIPS-image quality for KA3011A01 is presented in Table 3-1 and for KA3065A01 in Table 3-2.

Table 3-1. BIPS-image quality in KA3011A01.

From (m)	To (m)	Quality
1.85	99.90	Good

Table 3-2. BIPS-image quality in KA3065A01.

From (m)	To (m)	Quality
1.99	90.4	Good
90.4	115.6	Acceptable
115.6	125.25	Good

4 Execution

4.1 General

Mapping of the drill core of the boreholes was performed and documented according to activity plan AP TD TUDP002-11-87 (SKB, internal document) referring to the *Method Description for Boremap mapping* (SKB MD 143.006, v.2.0), *Nomenklatur vid Boremapkartering* (SKB MD 143.008, v.2.0), *Instruktion: Regler för bergarters benämningar vid platsundersökningen i Oskarshamn* (SKB MD 132.004, v.1.0) and *Instruktion för längdkalibrering vid undersökningar i kärnborrhål* (SKB MD 620.010, v.2.0).

The drill core was displayed on inclined roller tables and mapped in its entire length with the Boremap software. The core mapping was carried out without any detailed geological knowledge of the area but with access to geophysical logs from the borehole and rock samples.

The term *oxidation* has been used as an alteration type until the mapping of KLX05. However, research has shown that the red colour of the bedrock is actually not only a result of oxidation. Since April 2005 the term *red staining* is used instead of the term *oxidation.*

The mapping was performed in November 2011 and January 2012 by Seje Carlsten and Allan Stråhle (Geosigma AB).

4.1.1 Preparations

Any depth registered in the BIPS-image deviates from the true depth in the borehole, a deviation which increases with length, with approximately 0.4 m/100 m.

Necessary in data for length adjustment and orientation in space are borehole diameter, length and deviation; all data is collected from Sicada database (Appendices 6–8).

4.2 Execution of measurements

Concepts used during the core mapping, are defined in this chapter.

4.2.1 Fracture definitions

Definitions of different fracture types, aperture, crush zones and sealed fracture network are found in *Nomenklatur vid Boremapkartering* (SKB MD 143.008, v.2.0).

Two types of fractures are mapped in Boremap; broken and unbroken. Broken are fractures that split the core while unbroken fractures do not split the core. All fractures are described with their fracture minerals and other characteristics, e.g. width, aperture and roughness. Visible apertures are measured down to 1 mm in the BIPS-image. Smaller apertures, which are impossible to detect in the BIPS-image, are denoted a value of 0.5 mm. If the core pieces don't fit well, the aperture is considered "probable". If the core pieces do fit well, but the fracture surfaces are dull or altered, the aperture is considered "possible".

All fractures with apertures > 0 mm are treated as open in the Sicada database. Only few broken fractures are given the aperture = 0 mm. Unbroken fractures usually have apertures = 0 mm. Unbroken fractures that have apertures > 0 mm are interpreted as partly open and are included in the open-category. Open and sealed fractures are finally frequency calculated and shown in Appendix 1 and Appendix 2.

4.2.2 Fracture alteration and joint alteration number

Joint alteration number is principally related to the thickness of, and the clay content in a fracture. Thick fractures rich in clay minerals are given joint alteration numbers between 2 and 3. The majority of the broken fractures are very thin to extremely thin and seldom contain clay minerals. These fractures receive joint alteration numbers between 1 and 2.

A subdivision of fractures with joint alteration numbers between 1 and 2 was introduced to facilitate both the evaluation process for fracture alterations and the possibility to compare the alterations between different fractures in the boreholes. The subdivision is based on fracture mineralogy as follows:

a) fracture wall alterations,

b) fracture mineral fillings assumed to have been deposited from circulating water-rich solutions,

c) fracture mineral fillings most likely resulting from altered wall rock material.

Joint alteration number equal to 1: Fractures with or without wall rock alteration, e.g. oxidation or epidotization, and without mineral fillings is considered as fresh. The joint alteration number is thus set to 1.

Minerals such as calcite, quartz, fluorite, zeolites, laumontite and sulphides are regarded as deposited by circulating water-rich solutions and not as true fracture alteration minerals. The joint alteration number is thus set to 1.

Joint alteration number equal to 1.5: epidote, prehnite, hematite, chlorite and/or clay minerals are regarded as fracture minerals most likely resulting from altered wall rock. A weak alteration is thus assumed and the joint alteration number was set to 1.5. Extra considerations have been given to clay minerals since the occurrence of these minerals often resulted in a higher joint alteration number.

Joint alteration numbers higher than 1.5: When the mineral fillings is thick and contain a few mm of clay minerals, often together with epidote and chlorite, the joint alteration number is set to 2. In rare cases, when a fracture contains 5–10 mm thick clay, together with chlorite, the joint alteration number is set to 3 or higher.

When the alteration of a fracture is too thick (and/or intense) to give the fracture the joint alteration number 1.5 and too thin and/or weak to give it a 2, 1.7 and 1.8 is used.

4.2.3 Mapping of fractures not visible in the BIPS-image

Not all fractures are visible in the BIPS-images, and these fractures are orientated by using the *guide-line method*, based on the following data:

- Amplitude (measured along the drill core) which is the interval between fracture extremes along the drill core.
- The relation between the orientations of the fracture trace, measured on the drill core and a well defined structure visible in the BIPS-image.
- Absolute depth.

Orientation of fractures and other structures with the *guide-line method* is done in the following way: The first step is to calculate the amplitude of the fracture trace in the BIPS-image (with 76 mm diameter) from the measured fracture amplitude in the drill core (with 50 mm diameter). The second step is the correction of strike and dip. This is done by rotating the fracture trace in the BIPS-image relative to a feature with known orientation. The fracture trace is then put at the correct depth according to the depth measured on the drill core.

The *guide-line method* can be used to orientate any feature that is not visible in the BIPS-image. It is also a valuable tool to control that the personnel working with the drill core is observing the same feature as the personnel delineating the trace in the BIPS-image, especially in intervals rich in fractures.

The error of orientating fractures using the *guide-line method* is not known but experience and an estimation using stereographic plots indicated that the error is most likely insignificant. Accordingly, the *guide-line method* is so far considered better than mapping lots of non-oriented fractures. The fractures in question are mapped as “non-visible in BIPS” and can therefore be separated from fractures visible in BIPS which probably have a more accurate orientation.

4.2.4 Definition of veins and dikes

Rock occurrence is the way Boremap handles the occurrence of lithology up to 1 meter wide. Chiefly two different rock occurrences are mapped: veins and dikes. These two are separated by their respectively length in the drill core; veins are set to 0–20 cm and dikes are set to 20–100 cm. Rock occurrences that covers more than 100 cm of the drill core are mapped under the feature *rock type.*

4.2.5 Mineral codes

Properties and/or minerals are represented in the mineral list, following mineral codes.

4.3 Data handling

Mapping of the drill core is performed on-line on the SKB network, in order to obtain the best possible data security. Before every break (> 15 minutes) a back-up is saved on the local disk. Regular quality controls are performed. Every working day a Summary report (from Boremap) and a WellCAD plot are printed in order to find possible misprints. The mapping is also quality checked by a routine in Boremap before it is exported to and archived in Sicada database. Personnel from SKB also perform spot test controls and regular quality revisions. All primary data is stored in SKB’s database Sicada and only these data are later used for interpretation and modelling.

4.4 Geological summary table, general description

A Geological summary table (Appendix 1 and Appendix 2) is an overview of the features mapped with the Boremap software. It also facilitates comparisons between Boremap information collected from different boreholes and is more objective than a pure descriptive borehole summary. All information is taken directly from the Boremap database using simple and well defined search paths for each geological parameter.

The Geological summary table consists of 23 columns, each one representing a specific geological parameter, presented as either intervals or frequencies (see Section 4.5.1 for column description). Intervals are calculated for parameters with a width ≥ 1 m and frequencies for parameters with a width < 1 m. Frequency information is treated as treated as point observations. It should be noted that parameters with a thickness of only 1 mm get the same “value” as a similar parameter with a thickness of 999 mm since both are treated as point observations and used for frequency calculations.

Parameters are sometimes related in such a way that the mapping of one parameter cause a decrease in the frequency of another parameter. This type of intimate relationship between parameters has been noted for the following cases;

- There is a decrease in the frequency of *unbroken fractures* with oxidized walls and without mineral fillings in intervals mapped with *Alteration – red staining.*
- No *unbroken fractures* are mapped in intervals of *sealed fracture network*.
- No *broken fractures* are mapped in intervals with *crush.*
- Hybrid rock and composite dikes generally include a large amount of fine to medium grained granite veins. These veins are not mapped and the frequency presented for veins + dikes in column 6 (Appendix 1 and 2) are lower than the true frequency in composite dike intervals.

4.4.1 Columns in the Geological summary table

The Geological summary table includes the following 23 columns:

Column 1: *Rock Type / Lithology*, interval column. Only lithologies longer than 1 m are presented here. Shorter lithologies are presented in column 6. This column is identical with the ordinary WellCAD presentation.

Column 2: *Rock Type / Grain size*, interval column. Interval limits follows column 1. This column is identical with the ordinary WellCAD presentation.

Column 3: *Rock Type / Texture*, interval column. Interval limits follows column 1. This column is identical with the ordinary WellCAD presentation.

Column 4: *Alteration / Type*, interval column. No frequency column is presented for alteration/ red staining. The alteration/ red staining column are identical with the ordinary WellCAD presentation.

Column 5: *Alteration / intensity*, interval column. This column is identical with the ordinary WellCAD presentation.

Column 6: *Rock Occurrence / Veins + Dikes < 1 m wide*, frequency column. This rock type column can be seen as the frequency complement to the rock type/lithology interval column. Only rock type sections that are thinner than 1 m can be described as rock occurrences in Boremap. Thicker rock type sections are mapped as rock type.

Column 7: *Structure / Shear Zone < 1 m wide*, frequency column. This column includes ductile shear structures as well as brittle-ductile shear structures and these are mapped as rock occurrences in Boremap.

Column 8: *Structure / Brecciated < 1 m wide*, frequency column. Breccias < 1 m wide are mapped as rock occurrence in Boremap. Very thin micro breccias along sealed/natural fracture planes are generally not considered.

Column 9: *Structure / Brecciated ≥ 1 m wide*, interval column. Breccias > 1 m wide are mapped as rock type/structure in Boremap.

Column 10: *Structure / Mylonite < 1 m wide*, frequency column. Mylonites < 1 m wide are mapped as rock occurrence/structure in Boremap.

Column 11: *Structure / Mylonite ≥ 1 m wide* is an interval column. Mylonites > 1 m wide are mapped as rock type/structure in Boremap.

Column 12: *Structure / Foliation < 1 m wide* is a frequency column. Sections with foliation < 1 m wide are mapped as rock occurrence/structure in Boremap.

Column 13: *Structure / Foliation ≥ 1 m wide* is an interval column. Sections with foliation ≥ 1 m wide are mapped as rock type/structure in Boremap.

Column 14: *Sealed fractures / All*, frequency column. This column includes all fractures mapped as unbroken in the Boremap system as well as broken fractures interpreted to have broken up artificially during/after drilling.

Column 15: *Sealed fractures / Broken with aperture = 0*, frequency column. This column includes unbroken fractures interpreted to have broken up artificially during/after drilling.

Column 16: *Sealed fractures / Sealed Fracture Network < 1 m wide*, frequency column. The sealed fracture network parameter is the only parameter that is generally evaluated directly from observations of the drill core. These types of sealed fractures can only in rare cases be observed in the BIPS-image.

Column 17: *Sealed fractures / Sealed Fracture Network ≥ 1 m wide*, interval column.

Column 18: *Open fractures / All Apertures > 0*, frequency column. This column includes all broken fractures, both fractures that with certainty were open before drilling and fractures that probably or possibly were open before drilling.

Column 19: *Open fractures / Uncertain, Aperture = 0.5 probable + 0.5 possible*, frequency column. This column includes fractures that probably or possibly open before drilling.

Column 20: *Open fractures / Certain Aperture = 0.5 certain and > 0.5*, frequency column. This column includes fractures that certainly were open before drilling.

Column 21: *Open fractures / Joint alteration > 1.5*, frequency column. This column show fractures with stronger joint alteration than normal. This parameter is generally correlated with the location of lithologies with a more weathered appearance.

Column 22: *Open fractures / Crush < 1 m wide*, frequency column. This column includes shorter sections with crush.

Column 23: *Open fractures / Crush ≥ 1 m wide*, interval column. This column includes longer sections with crush.

5 Results from KA3011A01

5.1 General

Borehole KA3011A01 is oriented 055°/–1.2° at the start. The drill core covers the interval 0.00-100.15 m and the BIPS-image covers the interval 1.85–99.900 m.

All results from the mapping are principally found in the Appendices. Information from the Sicada database is shown in the Geological summary table in Appendix 1 and a search path to Geological summary table is presented in Appendix 3. The BIPS-image is presented in Appendix 4, the WellCAD diagram in Appendix 6 and In-data, such as borehole length, deviation data and diameter are presented in Appendices 10 and 12.

Original data from the reported activity are stored in the primary database Sicada. Data are traceable in Sicada by the activity plan number (AP TD TUDP002-11-87). Only data in the 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 revisions entail a revision of the P-report. Minor revisions are normally presented as supplements, available at *www.skb.se*.

5.2 Lithology and structures

The lithology in KA3011A01 (Table 5-1) is dominated by Ävrö granodiorite (501056) and to a lesser extent fine-grained granite (511058). In the lower half of the borehole the Ävrö granodiorite (501056) is intermingled with Äspö diorite (501037). A section with fine-grained granite (511058) occurs in the upper part of the borehole. Subordinate rock types comprise Äspö diorite (501037), pegmatite (501061) and fine-grained diorite-gabbro (505102).

One section in KA3011A01 is recognized by increased fracture frequencies, alterations and structural features;

Section interval characteristics;

1. 14–35 m. Increased frequency of open and sealed fractures together with foliation. Pyrite impregnation at c 16 m. Two crush occur within the section, and a brittle-ductile shear zone. Varying degrees of oxidation occurs in the section.

5.3 Fracture mineralogy

Tables 5-2 and 5-3 show the frequency of minerals and oxidized walls in sealed fractures and open fractures, respectively. Minerals less than 0.1% are not accounted for.

Chlorite, calcite and hematite are the most frequently occurring minerals in open fractures. Subordinate minerals are iron hydroxide, laumontite, pyrite, epidote, quartz and prehnite. In sealed fractures the dominating minerals are epidote, calcite, chlorite, quartz and hematite. Subordinate minerals are prehnite, laumontite, unknown mineral and pyrite. Also, oxidized walls occur in both open and sealed fractures.

Table 5-1. Lithology distribution in KA3011A01.

Rock types	%
Ävrö granodiorite (501056)	81.5
Fine-grained granite (511058)	12.9
Äspö diorite (501037)	5.2
Pegmatite (501061)	0.2
Fine-grained diorite-gabbro (505102)	0.2

Table 5-2. Frequency of minerals and oxidized walls in open fractures in KA3011A01.

Mineral	%
Chlorite	76.7
Calcite	58.0
Hematite	11.7
Iron Hydroxide	8.1
Laumontite	5.5
Pyrite	3.8
No detectable mineral	3.0
Epidote	2.7
Unknown mineral	0.8
Quartz	0.5
Oxidized walls	0.5
Prehnite	0.3

Table 5-3. Frequency of minerals and oxidized walls in sealed fractures in KA3011A01.

Mineral	%
Epidote	32.8
Calcite	29.9
Chlorite	28.2
Quartz	18.7
Hematite	12.0
Oxidized Walls	6.6
Prehnite	5.8
Laumontite	1.2
Unknown Mineral	0.4
Pyrite	1.3

6 Results from KA3065A01

6.1 General

Borehole KA3065A01 is oriented 055°/–0.6° at the start. The drill core covers the interval 0.00-125.25 m and the BIPS-image covers the interval 1.992–125.000 m.

All results from the mapping are principally found in the Appendices. Information from the Sicada database is shown in the Geological summary table in Appendix 2 and a search path to Geological summary table is presented in Appendix 3. The BIPS-image is presented in Appendix 5, the WellCAD diagram in Appendix 7 and In-data, such as borehole length, deviation data and diameter are presented in Appendices 11 and 13.

Original data from the reported activity are stored in the primary database Sicada. Data are traceable in Sicada by the activity plan number (AP TD TUDP002-11-87). Only data in the 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 revisions entail a revision of the P-report. Minor revisions are normally presented as supplements, available at *www.skb.se*.

6.2 Lithology and structures

The lithology in KA3065A01 (Table 6-1) is dominated by Äspö diorite (501037) and to a lesser extent by Ävrö granodiorite (501056). Two sections with Ävrö granodiorite (501056) occurs in the upper part of the borehole, separated by a section with fine-grained diorite-gabbro (505102). Fine-grained granite (511058) occurs in the end of the borehole. Subordinate rock types comprise fine-grained diorite-gabbro (505102), fine-grained granite (511058), pegmatite (501061), breccia (508002), and very sparse occurrence of mylonite (508004).

No section in KA3065A01 can be recognized by increased fracture frequencies, alterations or structural features.

6.3 Fracture mineralogy

Tables 6-2 and 6-3 show the frequency of minerals and oxidized walls in sealed fractures and open fractures, respectively. Minerals less than 0.1% are not accounted for.

Calcite and chlorite are the most frequently occurring minerals in open fractures. Subordinate minerals are hematite, epidote, pyrite, laumontite, iron hydroxide, quartz and clay minerals. In sealed fractures the dominating minerals are calcite, calcite, epidote and chlorite. Subordinate minerals are hematite, prehnite, laumontite, pyrite, asphalt and zeolite. Also, oxidized walls occur in both open and sealed fractures.

Table 6-1. Lithology distribution in KA3065A01.

Rock types	%
Äspö diorite (501037)	65.8
Ävrö granodiorite (501056)	20.6
Fine-grained diorite-gabbro (505102)	6.7
Fine-grained granite (511058)	6.4
Pegmatite (501061)	0.3
Breccia (508002)	0.2
Mylonite (508004)	0.0

Table 6-2. Frequency of minerals and oxidized walls in open fractures in KA3065A01.

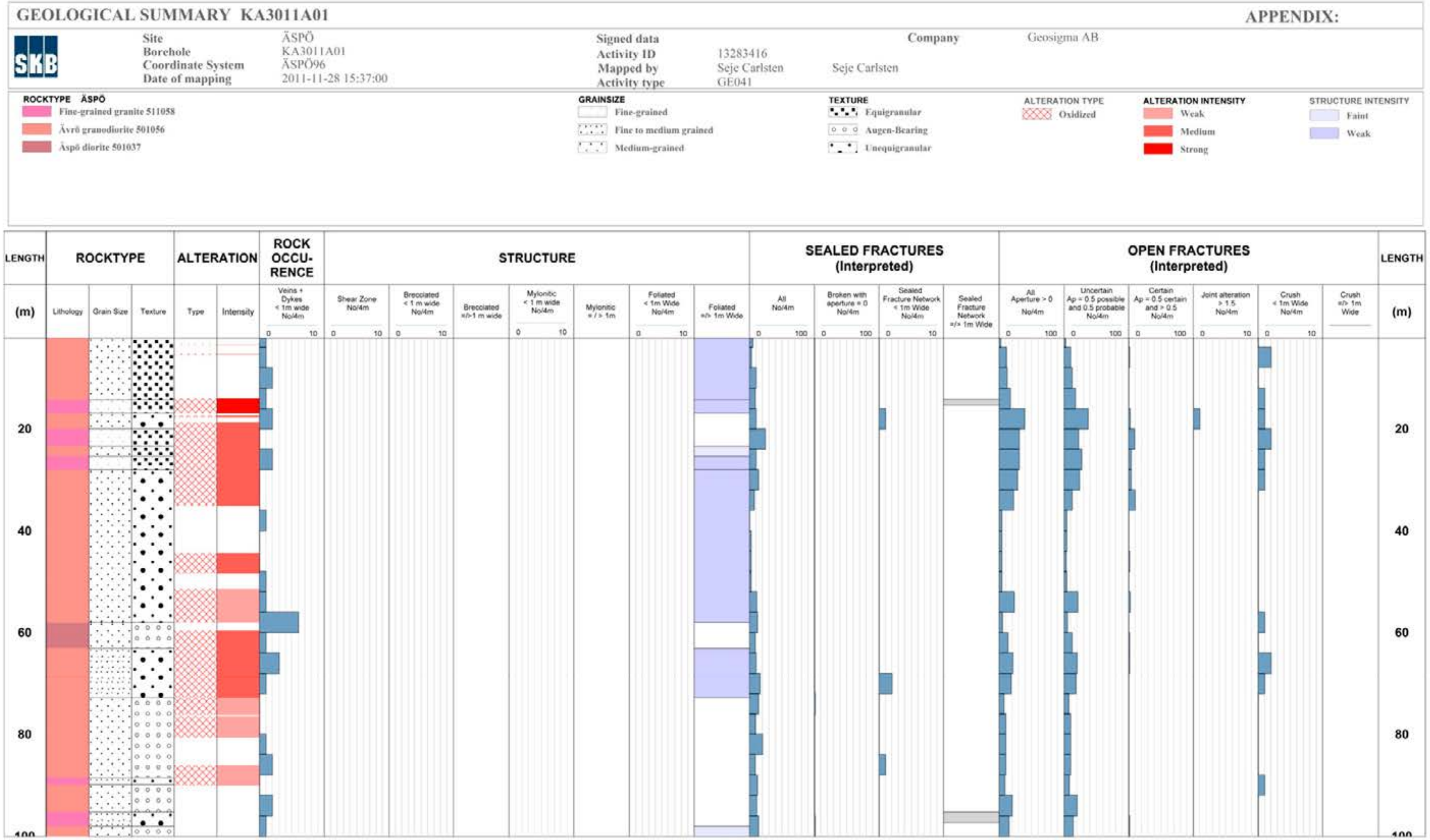
Mineral	%
Chlorite	78.6
Calcite	55.7
Hematite	14.5
Epidote	10.6
Pyrite	4.9
No detectable mineral	4.9
Oxidized walls	4.7
Laumontite	4.4
Iron Hydroxide	2.7
Quartz	2.5
Clay Minerals	0.5

Table 6-3. Frequency of minerals and oxidized walls in sealed fractures in KA3065A01.

Mineral	%
Quartz	40.5
Calcite	32.1
Epidote	31.3
Oxidized Walls	31.3
Chlorite	20.2
Hematite	6.9
Prehnite	5.3
Laumontite	4.6
No detectable mineral	0.4
Pyrite	0.4
Asphalt	0.4
Zeolite	0.4

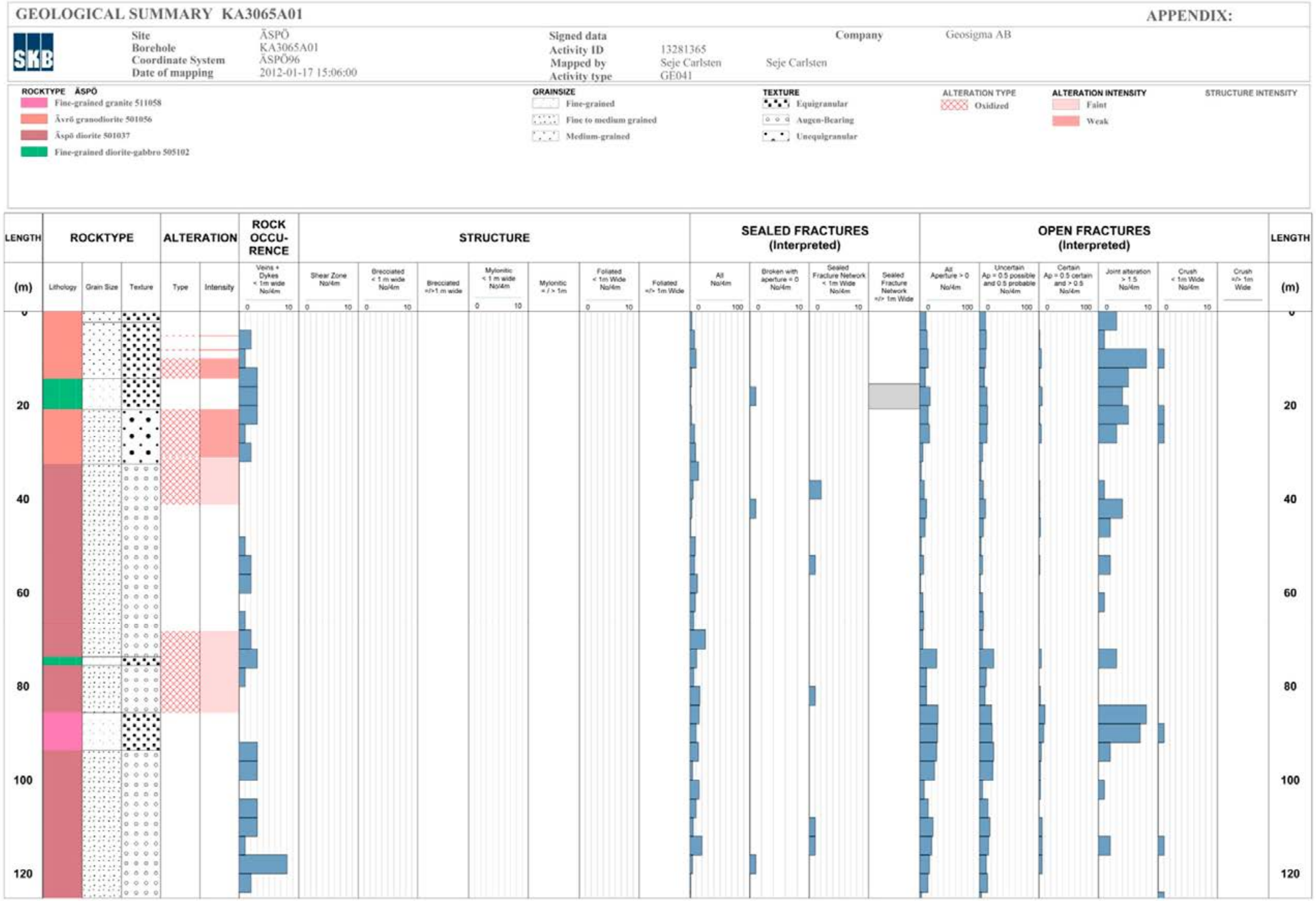
Appendix 1

Geological WellCAD summary table for KA3011A01



Appendix 2

Geological summary table for KA3065A01



Search paths for the Geological summary table

Table head lines		Information source			Presentation
Head lines	**Sub head lines**	**Varcode**	**First suborder**	**Second suborder**	**Interval / frequence**
Rock type	Lithology	5	Sub 1		Interval
	Grain size	5	Sub 5		Interval
	Texture	5	Sub 6		Interval
Alteration	Oxidation	7	Sub 1 = 700		Interval
	Oxidation intensity	7	Sub 1 = 700	Sub 2	Interval
Rock occurrence	Vein + dyke	31	Sub 1 = 2 and 18		Frequence
Structure	Shear zone	31	Sub 4 = 41 and 42		Frequence
	Brecciated, < 1 m wide	31	Sub 4 = 7		Frequence
	Brecciated, >/= 1 m wide	5 5	Sub 3 = 7 Sub 3 = 7	Sub 4; 101 and 102 = 102 Sub 4; 103 and 104 = 104	Interval
	Mylonite, < 1 m wide	31	Sub 4 = 34		Frequence
	Mylonite, >/= 1 m wide	5 5	Sub 3 = 34 Sub 3 = 34	Sub 4; 101 and 102 = 102 Sub 4; 103 and 104 = 104	Interval
	Foliation zone, < 1 m wide	31	Sub 4 = 81		Frequence
	Foliation zone, >/= 1 m wide	5 5	Sub 3 = 81 Sub 3 = 81	Sub 4; 101 and 102 = 102 Sub 4; 103 and 104 = 104	Interval
Sealed fracture	All unbroken fractures and broken fractures	3 2	 SNUM 11 = 0		Frequence
	Broken fractures, Aperture = 0	2	SNum 11 = 0		Frequence
	Sealed fracture network < 1 m wide	32			Frequence
	Sealed fracture network >/= 1 m wide	32			Interval
Open fractures	All, Aperture > 0	2 and 3	SNum 11 > 0		Frequence
	Uncertain, Aperture = 0.5 possible and 0.5 probable	2 and 3	SNum 11 > 0	Sub 12 > 1	Frequence
	Certain, Aperture = 0.5 certain	2 and 3	SNum 11 > 0	Sub 12 = 1	Frequence
	Joint alteration > 1.5	2	SNum16 > 1.5		Frequence
	Crush < 1 m wide	4			Frequence
	Crush >/= 1 m wide	4			Interval

Appendix 4

BIPS-image for KA3011A01

Borehole Image Report

Borehole Name:	KA3011A01
Mapping Name:	KA3011A01_Geosigma_5
Mapping Range:	1.852–100.200 m
Diameter:	76.0 mm
Printed Range:	2.000–99.900
Pages:	6

Image File Information:

File: K:\60_Externt\6026xx\602641_Boremapkartering KA3011A01 KA3065A01 Äspö HRL \Arbetsdata\KA3011A01_2-100m_201111221812.BIP

Date/Time:	2011-11-22 18:12:00
Start Depth:	1.852 m
End Depth:	99.900 m
Resolution:	1.00 mm/pixel (depth)
Orientation:	Gravimetric
Image height:	98,048 pixels
Image width:	360 pixels
BIP Version:	BIP-III
Locality:	ASPO HRL
Borehole:	KA3011A1
Scan Direction:	Up
Color adjust:	0 0 0 (RGB)

Borehole: KA3011A01
Mapping: KA3011A01_Geosigma_5

Depth range: 2.000 - 22.000 m
Azimuth: 55.0
Inclination: -0.9

2.000	1.918
2.200	2.008
2.400	2.098
2.600	2.187
2.800	2.335
3.000	2.536
3.200	2.737
3.400	2.937
3.600	3.138
3.800	3.339
4.000	3.539
4.200	3.740
4.400	3.941
4.600	4.141
4.800	4.342
5.000	4.543
5.200	4.743
5.400	4.944
5.600	5.145
5.800	5.345

6.000	5.546
6.200	5.747
6.400	5.947
6.600	6.148
6.800	6.349
7.000	6.549
7.200	6.750
7.400	6.951
7.600	7.151
7.800	7.352
8.000	7.553
8.200	7.753
8.400	7.954
8.600	8.155
8.800	8.355
9.000	8.556
9.200	8.757
9.400	8.957
9.600	9.158
9.800	9.359

10.000	9.559
10.200	9.760
10.400	9.961
10.600	10.161
10.800	10.362
11.000	10.563
11.200	10.763
11.400	10.964
11.600	11.165
11.800	11.365
12.000	11.566
12.200	11.767
12.400	11.967
12.600	12.168
12.800	12.369
13.000	12.569
13.200	12.770
13.400	12.971
13.600	13.171
13.800	13.372

14.000	13.573
14.200	13.773
14.400	13.974
14.600	14.175
14.800	14.375
15.000	14.576
15.200	14.777
15.400	14.977
15.600	15.178
15.800	15.379
16.000	15.579
16.200	15.780
16.400	15.981
16.600	16.181
16.800	16.382
17.000	16.583
17.200	16.783
17.400	16.984
17.600	17.185
17.800	17.385

18.000	17.586
18.200	17.787
18.400	17.987
18.600	18.188
18.800	18.389
19.000	18.589
19.200	18.790
19.400	18.991
19.600	19.191
19.800	19.392
20.000	19.593
20.200	19.793
20.400	19.994
20.600	20.195
20.800	20.395
21.000	20.596
21.200	20.797
21.400	20.997
21.600	21.198
21.800	21.399

Printed: 2012-11-15 10:51:12 Scale: 1 : 20 Aspect: 150 % 2 (6)

Borehole: KA3011A01
Mapping: KA3011A01_Geosigma_5

Depth range: 22.000 - 42.000 m
Azimuth: 55.0
Inclination: -0.8

22.000
21.599
22.200
21.800
22.400
22.001
22.600
22.201
22.800
22.402
23.000
22.603
23.200
22.803
23.400
23.004
23.600
23.205
23.800
23.405
24.000
23.606
24.200
23.807
24.400
24.007
24.600
24.208
24.800
24.409
25.000
24.609
25.200
24.810
25.400
25.011
25.600
25.211
25.800
25.412

26.000
25.613
26.200
25.813
26.400
26.014
26.600
26.215
26.800
26.415
27.000
26.616
27.200
26.817
27.400
27.017
27.600
27.218
27.800
27.419
28.000
27.619
28.200
27.820
28.400
28.021
28.600
28.221
28.800
28.422
29.000
28.623
29.200
28.823
29.400
29.024
29.600
29.225
29.800
29.425

30.000
29.626
30.200
29.827
30.400
30.027
30.600
30.228
30.800
30.429
31.000
30.629
31.200
30.830
31.400
31.031
31.600
31.231
31.800
31.432
32.000
31.633
32.200
31.833
32.400
32.034
32.600
32.235
32.800
32.435
33.000
32.636
33.200
32.837
33.400
33.037
33.600
33.238
33.800
33.439

34.000
33.639
34.200
33.840
34.400
34.041
34.600
34.241
34.800
34.442
35.000
34.643
35.200
34.843
35.400
35.044
35.600
35.245
35.800
35.445
36.000
35.646
36.200
35.847
36.400
36.047
36.600
36.248
36.800
36.449
37.000
36.649
37.200
36.850
37.400
37.051
37.600
37.251
37.800
37.452

38.000
37.653
38.200
37.853
38.400
38.054
38.600
38.255
38.800
38.455
39.000
38.656
39.200
38.857
39.400
39.057
39.600
39.258
39.800
39.459
40.000
39.659
40.200
39.860
40.400
40.061
40.600
40.261
40.800
40.462
41.000
40.663
41.200
40.863
41.400
41.064
41.600
41.265
41.800
41.465

Printed: 2012-11-15 10:51:12 Scale: 1 : 20 Aspect: 150 % 3 (6)

Borehole: KA3011A01
Mapping: KA3011A01_Geosigma_5

Depth range: 42.000 - 62.000 m
Azimuth: 55.1
Inclination: -0.8

42.000	41.666
42.200	41.867
42.400	42.067
42.600	42.268
42.800	42.469
43.000	42.669
43.200	42.870
43.400	43.071
43.600	43.271
43.800	43.472
44.000	43.673
44.200	43.873
44.400	44.074
44.600	44.275
44.800	44.475
45.000	44.676
45.200	44.877
45.400	45.077
45.600	45.278
45.800	45.479

46.000	45.679
46.200	45.880
46.400	46.081
46.600	46.281
46.800	46.482
47.000	46.683
47.200	46.883
47.400	47.084
47.600	47.285
47.800	47.485
48.000	47.686
48.200	47.887
48.400	48.087
48.600	48.288
48.800	48.489
49.000	48.689
49.200	48.890
49.400	49.091
49.600	49.291
49.800	49.492

50.000	49.693
50.200	49.893
50.400	50.094
50.600	50.295
50.800	50.495
51.000	50.696
51.200	50.897
51.400	51.097
51.600	51.298
51.800	51.499
52.000	51.699
52.200	51.900
52.400	52.101
52.600	52.301
52.800	52.502
53.000	52.703
53.200	52.903
53.400	53.104
53.600	53.305
53.800	53.505

54.000	53.706
54.200	53.907
54.400	54.107
54.600	54.308
54.800	54.509
55.000	54.709
55.200	54.910
55.400	55.111
55.600	55.311
55.800	55.512
56.000	55.713
56.200	55.913
56.400	56.114
56.600	56.315
56.800	56.515
57.000	56.716
57.200	56.917
57.400	57.117
57.600	57.318
57.800	57.519

58.000	57.719
58.200	57.920
58.400	58.121
58.600	58.321
58.800	58.522
59.000	58.723
59.200	58.923
59.400	59.124
59.600	59.325
59.800	59.525
60.000	59.726
60.200	59.927
60.400	60.127
60.600	60.328
60.800	60.529
61.000	60.729
61.200	60.930
61.400	61.131
61.600	61.331
61.800	61.532

Printed: 2012-11-15 10:51:12   Scale: 1 : 20   Aspect: 150 %   4 (6)

Borehole: KA3011A01
Mapping: KA3011A01_Geosigma_5

Depth range: 62.000 - 82.000 m
Azimuth: 54.6
Inclination: -0.7

62.000	61.733
62.200	61.933
62.400	62.134
62.600	62.335
62.800	62.535
63.000	62.736
63.200	62.937
63.400	63.137
63.600	63.338
63.800	63.539
64.000	63.739
64.200	63.940
64.400	64.141
64.600	64.341
64.800	64.542
65.000	64.743
65.200	64.943
65.400	65.144
65.600	65.345
65.800	65.545

66.000	65.746
66.200	65.947
66.400	66.147
66.600	66.348
66.800	66.549
67.000	66.749
67.200	66.950
67.400	67.151
67.600	67.351
67.800	67.552
68.000	67.753
68.200	67.953
68.400	68.154
68.600	68.355
68.800	68.555
69.000	68.756
69.200	68.957
69.400	69.157
69.600	69.358
69.800	69.559

70.000	69.759
70.200	69.960
70.400	70.161
70.600	70.361
70.800	70.562
71.000	70.763
71.200	70.963
71.400	71.164
71.600	71.365
71.800	71.565
72.000	71.766
72.200	71.967
72.400	72.167
72.600	72.368
72.800	72.569
73.000	72.769
73.200	72.970
73.400	73.171
73.600	73.371
73.800	73.572

74.000	73.773
74.200	73.973
74.400	74.174
74.600	74.375
74.800	74.575
75.000	74.776
75.200	74.977
75.400	75.177
75.600	75.378
75.800	75.579
76.000	75.779
76.200	75.980
76.400	76.181
76.600	76.381
76.800	76.582
77.000	76.783
77.200	76.983
77.400	77.184
77.600	77.385
77.800	77.585

78.000	77.786
78.200	77.987
78.400	78.187
78.600	78.388
78.800	78.589
79.000	78.789
79.200	78.990
79.400	79.191
79.600	79.391
79.800	79.592
80.000	79.793
80.200	79.993
80.400	80.194
80.600	80.395
80.800	80.595
81.000	80.796
81.200	80.997
81.400	81.197
81.600	81.398
81.800	81.599

Printed: 2012-11-15 10:51:12   Scale: 1 : 20   Aspect: 150 %   5 (6)

Borehole: KA3011A01
Mapping: KA3011A01_Geosigma_5

Depth range: 82.000 - 99.900 m
Azimuth: 54.6
Inclination: -0.6





82.000	81.799	86.000	85.813	90.000	89.826	94.000	93.839	98.000	97.853
82.200	82.000	86.200	86.013	90.200	90.027	94.200	94.040	98.200	98.053
82.400	82.201	86.400	86.214	90.400	90.227	94.400	94.241	98.400	98.254
82.600	82.401	86.600	86.415	90.600	90.428	94.600	94.441	98.600	98.455
82.800	82.602	86.800	86.615	90.800	90.629	94.800	94.642	98.800	98.655
83.000	82.803	87.000	86.816	91.000	90.829	95.000	94.843	99.000	98.856
83.200	83.003	87.200	87.017	91.200	91.030	95.200	95.043	99.200	99.057
83.400	83.204	87.400	87.217	91.400	91.231	95.400	95.244	99.400	99.257
83.600	83.405	87.600	87.418	91.600	91.431	95.600	95.445	99.600	99.458
83.800	83.605	87.800	87.619	91.800	91.632	95.800	95.645	99.800	99.659
84.000	83.806	88.000	87.819	92.000	91.833	96.000	95.846	100.000	99.859
84.200	84.007	88.200	88.020	92.200	92.033	96.200	96.047	100.200	100.060
84.400	84.207	88.400	88.221	92.400	92.234	96.400	96.247	100.400	
84.600	84.408	88.600	88.421	92.600	92.435	96.600	96.448	100.600	
84.800	84.609	88.800	88.622	92.800	92.635	96.800	96.649	100.800	
85.000	84.809	89.000	88.823	93.000	92.836	97.000	96.849	101.000	
85.200	85.010	89.200	89.023	93.200	93.037	97.200	97.050	101.200	
85.400	85.211	89.400	89.224	93.400	93.237	97.400	97.251	101.400	
85.600	85.411	89.600	89.425	93.600	93.438	97.600	97.451	101.600	
85.800	85.612	89.800	89.625	93.800	93.639	97.800	97.652	101.800	

Printed: 2012-11-15 10:51:12 Scale: 1 : 20 Aspect: 150 % 6 (6)

Appendix 5

BIPS-image for KA3065A01

Borehole Image Report

Borehole Name:	KA3065A01
Mapping Name:	KA3065A01_GE041_Geo5
Mapping Range:	0.000–125.201 m
Diameter:	76.0 mm
Printed Range:	2.000–125.000
Pages:	8

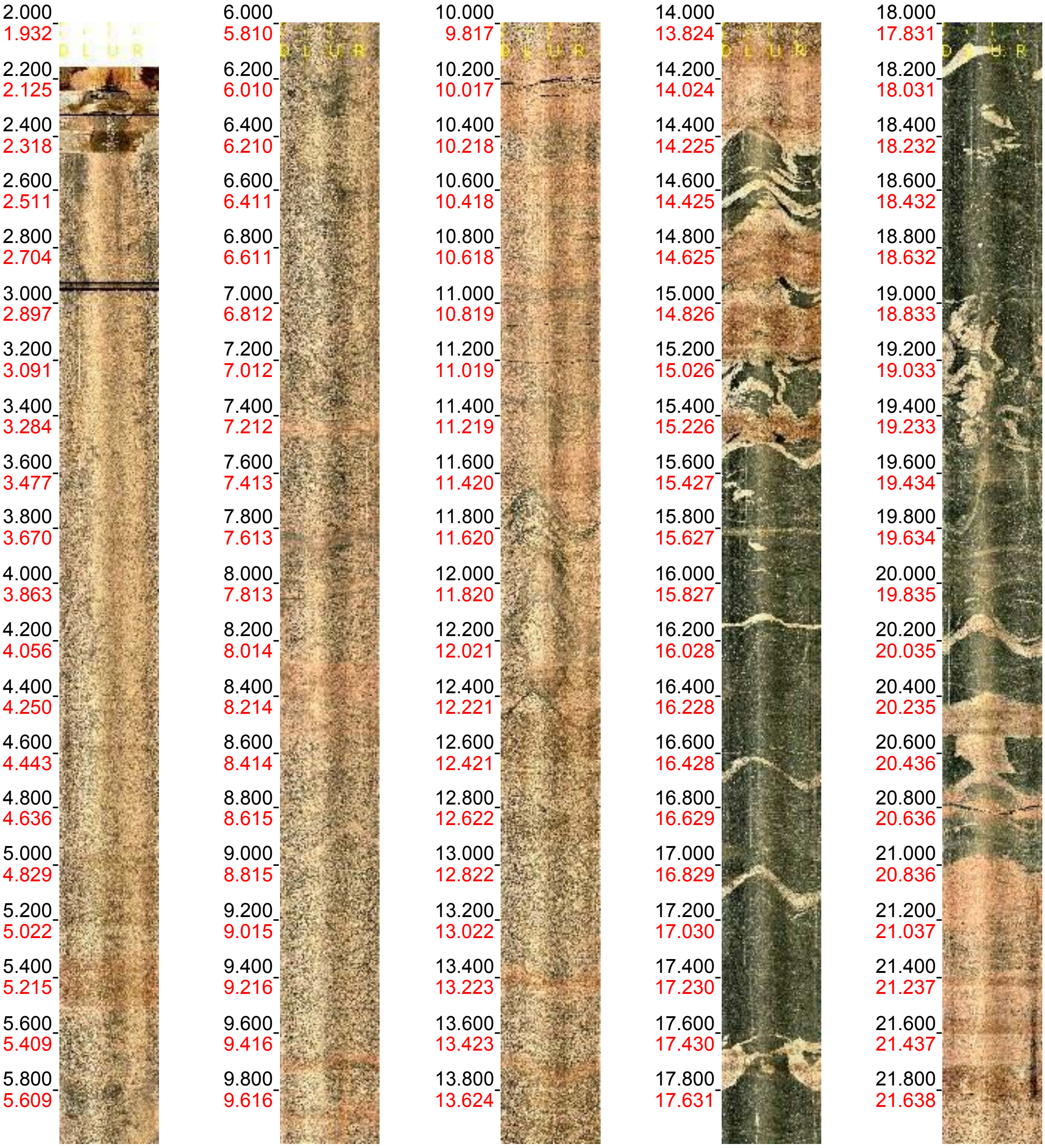
Image File Information:

File: K:\60_Externt\6026xx\602641_Boremapkartering KA3011A01 KA3065A01 Äspö HRL \Arbetsdata\KA3065A01_2-125m_201112191025.BIP

Date/Time:	2011-12-19 10:25:00
Start Depth:	1.992 m
End Depth:	125.000 m
Resolution:	1.00 mm/pixel (depth)
Orientation:	Gravimetric
Image height:	123,008 pixels
Image width:	360 pixels BIP
Version:	BIP-III
Locality:	ASPO HRL
Borehole:	KA3065A1
Scan Direction:	Up
Color adjust:	0 0 0 (RGB)

Borehole: KA3065A01
Mapping: KA3065A01_GE041_Geo5

Depth range: 2.000 - 22.000 m
Azimuth: 55.4
Inclination: -0.6



Printed: 2012-11-15 10:48:26 Scale: 1 : 20 Aspect: 150 % 2 (8)

Borehole: KA3065A01
Mapping: KA3065A01_GE041_Geo5

Depth range: 22.000 - 42.000 m
Azimuth: 55.0
Inclination: -0.6

Printed: 2012-11-15 10:48:26 Scale: 1 : 20 Aspect: 150 % 3 (8)

Borehole: KA3065A01
Mapping: KA3065A01_GE041_Geo5

Depth range: 42.000 - 62.000 m
Azimuth: 55.2
Inclination: -0.5

42.000
41.873
42.200
42.074
42.400
42.274
42.600
42.475
42.800
42.675
43.000
42.875
43.200
43.076
43.400
43.276
43.600
43.476
43.800
43.677
44.000
43.877
44.200
44.077
44.400
44.278
44.600
44.478
44.800
44.678
45.000
44.879
45.200
45.079
45.400
45.279
45.600
45.480
45.800
45.680

46.000
45.881
46.200
46.081
46.400
46.281
46.600
46.482
46.800
46.682
47.000
46.882
47.200
47.083
47.400
47.283
47.600
47.483
47.800
47.684
48.000
47.884
48.200
48.084
48.400
48.285
48.600
48.485
48.800
48.686
49.000
48.886
49.200
49.086
49.400
49.287
49.600
49.487
49.800
49.687

50.000
49.888
50.200
50.088
50.400
50.288
50.600
50.489
50.800
50.689
51.000
50.889
51.200
51.090
51.400
51.290
51.600
51.490
51.800
51.691
52.000
51.891
52.200
52.092
52.400
52.292
52.600
52.492
52.800
52.693
53.000
52.893
53.200
53.093
53.400
53.294
53.600
53.494
53.800
53.694

54.000
53.895
54.200
54.095
54.400
54.295
54.600
54.496
54.800
54.696
55.000
54.896
55.200
55.097
55.400
55.297
55.600
55.498
55.800
55.698
56.000
55.898
56.200
56.099
56.400
56.299
56.600
56.499
56.800
56.700
57.000
56.900
57.200
57.100
57.400
57.301
57.600
57.501
57.800
57.701

58.000
57.902
58.200
58.102
58.400
58.303
58.600
58.503
58.800
58.703
59.000
58.904
59.200
59.104
59.400
59.304
59.600
59.505
59.800
59.705
60.000
59.905
60.200
60.106
60.400
60.306
60.600
60.506
60.800
60.707
61.000
60.907
61.200
61.107
61.400
61.308
61.600
61.508
61.800
61.709

Printed: 2012-11-15 10:48:26   Scale: 1 : 20   Aspect: 150 %   4 (8)

Borehole: KA3065A01
Mapping: KA3065A01_GE041_Geo5

Depth range: 62.000 - 82.000 m
Azimuth: 54.9
Inclination: -0.3

62.000
61.909
62.200
62.109
62.400
62.310
62.600
62.510
62.800
62.710
63.000
62.911
63.200
63.111
63.400
63.311
63.600
63.512
63.800
63.712
64.000
63.912
64.200
64.113
64.400
64.313
64.600
64.513
64.800
64.714
65.000
64.914
65.200
65.115
65.400
65.315
65.600
65.515
65.800
65.716

66.000
65.916
66.200
66.116
66.400
66.317
66.600
66.517
66.800
66.717
67.000
66.918
67.200
67.118
67.400
67.318
67.600
67.519
67.800
67.719
68.000
67.919
68.200
68.120
68.400
68.320
68.600
68.521
68.800
68.721
69.000
68.921
69.200
69.122
69.400
69.322
69.600
69.522
69.800
69.723

70.000
69.923
70.200
70.123
70.400
70.324
70.600
70.524
70.800
70.724
71.000
70.925
71.200
71.125
71.400
71.326
71.600
71.526
71.800
71.726
72.000
71.927
72.200
72.127
72.400
72.327
72.600
72.528
72.800
72.728
73.000
72.928
73.200
73.129
73.400
73.329
73.600
73.529
73.800
73.730

74.000
73.930
74.200
74.130
74.400
74.331
74.600
74.531
74.800
74.732
75.000
74.932
75.200
75.132
75.400
75.333
75.600
75.533
75.800
75.733
76.000
75.934
76.200
76.134
76.400
76.334
76.600
76.535
76.800
76.735
77.000
76.935
77.200
77.136
77.400
77.336
77.600
77.536
77.800
77.737

78.000
77.937
78.200
78.138
78.400
78.338
78.600
78.538
78.800
78.739
79.000
78.939
79.200
79.139
79.400
79.340
79.600
79.540
79.800
79.740
80.000
79.941
80.200
80.141
80.400
80.341
80.600
80.542
80.800
80.742
81.000
80.943
81.200
81.143
81.400
81.343
81.600
81.544
81.800
81.744

Printed: 2012-11-15 10:48:26   Scale: 1 : 20   Aspect: 150 %   5 (8)

Borehole: KA3065A01
Mapping: KA3065A01_GE041_Geo5

Depth range: 82.000 - 102.000 m
Azimuth: 54.9
Inclination: -0.1

82.000 81.944
82.200 82.145
82.400 82.345
82.600 82.545
82.800 82.746
83.000 82.946
83.200 83.146
83.400 83.347
83.600 83.547
83.800 83.747
84.000 83.948
84.200 84.148
84.400 84.349
84.600 84.549
84.800 84.749
85.000 84.950
85.200 85.150
85.400 85.350
85.600 85.551
85.800 85.751

86.000 85.951
86.200 86.152
86.400 86.352
86.600 86.552
86.800 86.753
87.000 86.953
87.200 87.153
87.400 87.354
87.600 87.554
87.800 87.755
88.000 87.955
88.200 88.155
88.400 88.356
88.600 88.556
88.800 88.756
89.000 88.957
89.200 89.157
89.400 89.357
89.600 89.558
89.800 89.758

90.000 89.958
90.200 90.159
90.400 90.359
90.600 90.560
90.800 90.760
91.000 90.960
91.200 91.161
91.400 91.361
91.600 91.561
91.800 91.762
92.000 91.962
92.200 92.162
92.400 92.363
92.600 92.563
92.800 92.763
93.000 92.964
93.200 93.164
93.400 93.364
93.600 93.565
93.800 93.765

94.000 93.966
94.200 94.166
94.400 94.366
94.600 94.567
94.800 94.767
95.000 94.967
95.200 95.168
95.400 95.368
95.600 95.568
95.800 95.769
96.000 95.969
96.200 96.169
96.400 96.370
96.600 96.570
96.800 96.770
97.000 96.971
97.200 97.171
97.400 97.372
97.600 97.572
97.800 97.772

98.000 97.973
98.200 98.173
98.400 98.373
98.600 98.574
98.800 98.774
99.000 98.974
99.200 99.175
99.400 99.375
99.600 99.575
99.800 99.776
100.000 99.976
100.200 100.176
100.400 100.377
100.600 100.577
100.800 100.778
101.000 100.978
101.200 101.178
101.400 101.379
101.600 101.579
101.800 101.779

Printed: 2012-11-15 10:48:26 Scale: 1 : 20 Aspect: 150 % 6 (8)

Borehole: KA3065A01
Mapping: KA3065A01_GE041_Geo5

Depth range: 102.000 - 122.000 m
Azimuth: 54.5
Inclination: -0.1

102.000
101.980
102.200
102.180
102.400
102.380
102.600
102.581
102.800
102.781
103.000
102.981
103.200
103.182
103.400
103.382
103.600
103.583
103.800
103.783
104.000
103.983
104.200
104.184
104.400
104.384
104.600
104.584
104.800
104.785
105.000
104.985
105.200
105.185
105.400
105.386
105.600
105.586
105.800
105.786

106.000
105.987
106.200
106.187
106.400
106.387
106.600
106.588
106.800
106.788
107.000
106.989
107.200
107.189
107.400
107.389
107.600
107.590
107.800
107.790
108.000
107.990
108.200
108.191
108.400
108.391
108.600
108.591
108.800
108.792
109.000
108.992
109.200
109.192
109.400
109.393
109.600
109.593
109.800
109.794

110.000
109.994
110.200
110.194
110.400
110.395
110.600
110.595
110.800
110.795
111.000
110.996
111.200
111.196
111.400
111.396
111.600
111.597
111.800
111.797
112.000
111.997
112.200
112.198
112.400
112.398
112.600
112.598
112.800
112.799
113.000
112.999
113.200
113.200
113.400
113.400
113.600
113.600
113.800
113.801

114.000
114.001
114.200
114.201
114.400
114.402
114.600
114.602
114.800
114.802
115.000
115.003
115.200
115.203
115.400
115.403
115.600
115.604
115.800
115.804
116.000
116.004
116.200
116.205
116.400
116.405
116.600
116.606
116.800
116.806
117.000
117.006
117.200
117.207
117.400
117.407
117.600
117.607
117.800
117.808

118.000
118.008
118.200
118.208
118.400
118.409
118.600
118.609
118.800
118.809
119.000
119.010
119.200
119.210
119.400
119.410
119.600
119.611
119.800
119.811
120.000
120.012
120.200
120.212
120.400
120.412
120.600
120.613
120.800
120.813
121.000
121.013
121.200
121.214
121.400
121.414
121.600
121.614
121.800
121.815

Printed: 2012-11-15 10:48:26 Scale: 1 : 20 Aspect: 150 % 7 (8)

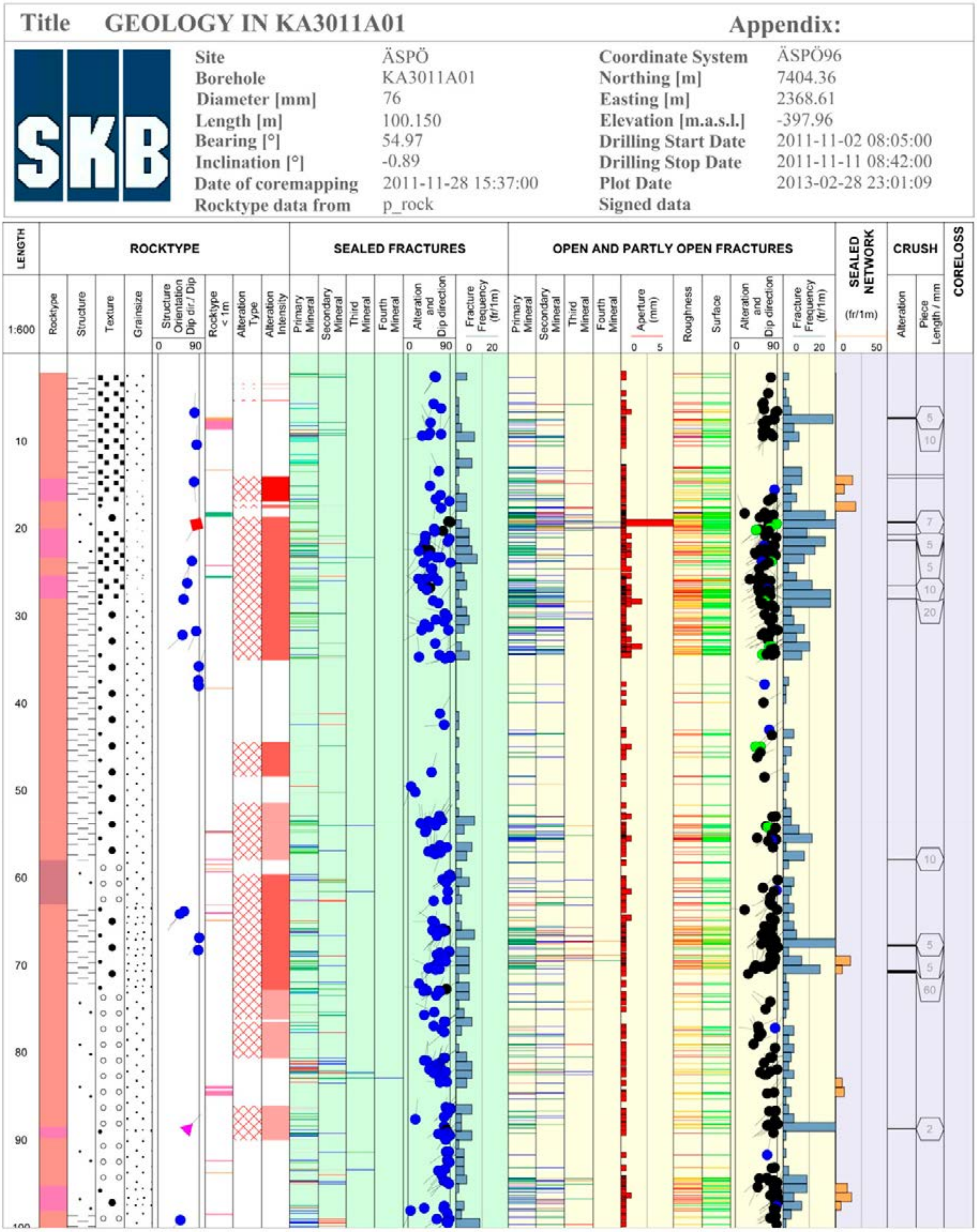
Borehole: KA30G5A01
Mapping: KA30G5A01_GE041_Geo5

Depth range: 122.000 - 125.000 m
Azimuth: 54.5
Inclination: -0.1

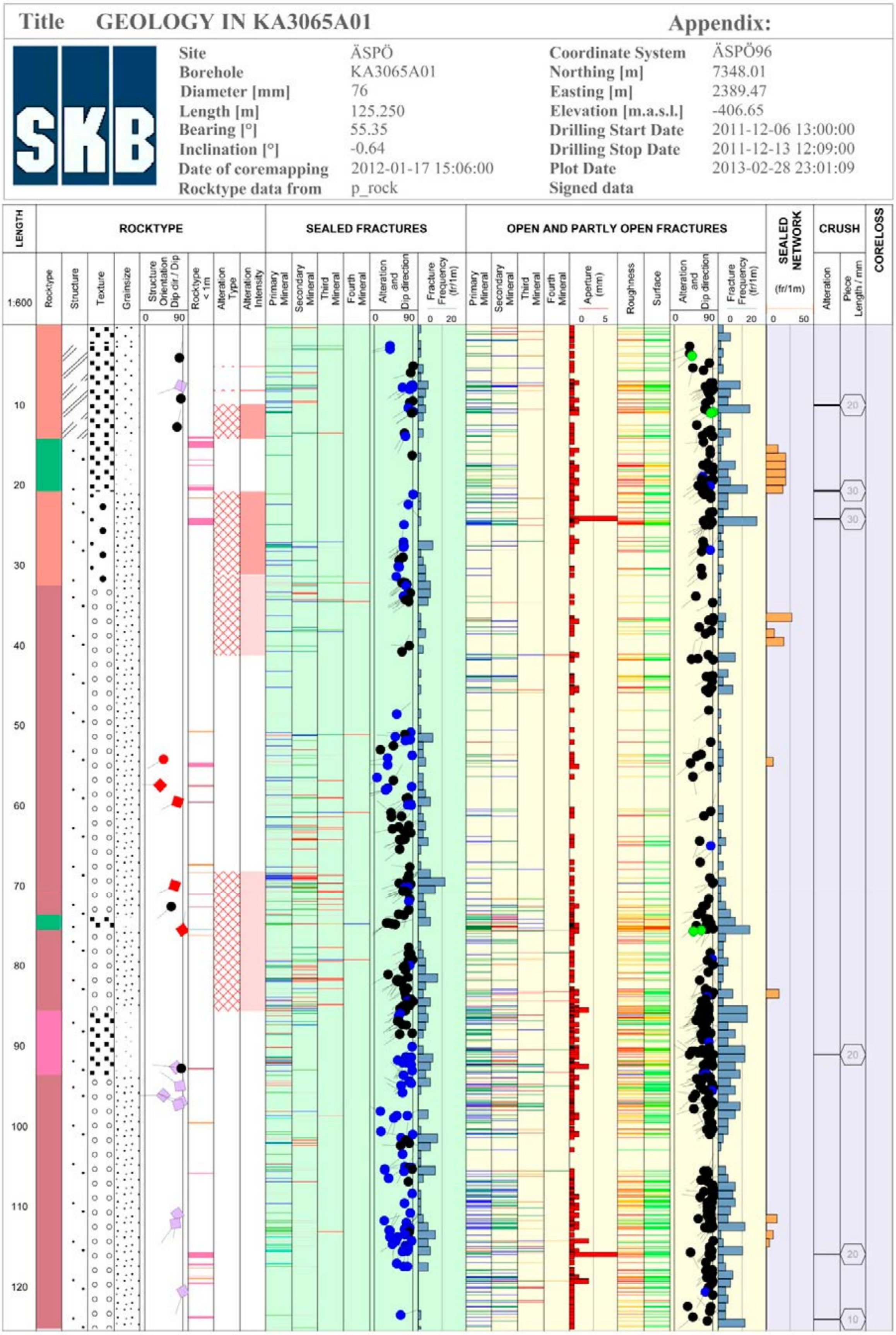
Printed: 2012-11-15 10:48:26 Scale: 1 :20 Aspect: 150% B (B)

Appendix 6

WellCAD diagram for KA3011A01



WellCAD diagram for KA3065A01



Legend to WellCAD diagram for KA3011A01

Appendix 9

Legend to WellCAD diagram for KA3065A01

Appendix 10

In-data: Borehole length and diameter for KA3011A01

Hole Diam T – Drilling: Borehole diameter

KA3011A01, 2011-11-02 08:05:00–2011-11-11 08:42:00 (0.000–100.150 m)

Sub Secup (m)	Sub Seclow (m)	Hole Diam (m)	Comment	QC
0.000	2.230	0.1160		*
2.230	100.150	0.0758	Corac N/3	*

Printout from Sicada 2012-11-14 12:57:33.

Appendix 11

In-data: Borehole length and diameter for KA3065A01

Hole Diam T – Drilling: Borehole diameter

KA3065A01, 2011-12-06 13:00:00–2011-12-13 12:09:00 (0.000–125.250 m)

Sub Secup (m)	Sub Seclow (m)	Hole Diam (m)	Comment	QC
0.000	2.290	0.1160		*
2.290	125.250	0.0758	Corac N/3	*

Printout from Sicada 2012-11-14 13:01:25.

Appendix 12

In-data: Borehole deviation data for KA3011A01

Sicada – Coordinate Information for KA3011A01 (Object type: Cored borehole

Northing (m)	Easting (m)	Elevation (m)	Coordinate System	Length (m)	Vertical Depth (m)	Inclination (degrees)	Bearing (degrees)	Inclination Uncertainty	Bearing Uncertainty	Radius Uncertainty	Calc Date
7,404.36	2,368.61	–397.97	ÄSPÖ96	0.00	0.00	–0.90	54.97	0.209	1.074	0.00	2012-06-07 11:21
7,406.08	2,371.07	–398.02	ÄSPÖ96	3.00	0.05	–0.90	54.97	0.209	1.074	0.06	2012-06-07 11:21
7,407.81	2,373.53	–398.07	ÄSPÖ96	6.00	0.09	–0.90	54.91	0.209	1.074	0.11	2012-06-07 11:21
7,409.53	2,375.98	–398.11	ÄSPÖ96	9.00	0.14	–0.90	54.97	0.209	1.074	0.17	2012-06-07 11:21
7,411.25	2,378.44	–398.16	ÄSPÖ96	12.00	0.19	–0.90	55.07	0.209	1.074	0.22	2012-06-07 11:21
7,412.97	2,380.90	–398.21	ÄSPÖ96	15.00	0.23	–0.89	55.07	0.209	1.074	0.28	2012-06-07 11:21
7,414.68	2,383.36	–398.25	ÄSPÖ96	18.00	0.28	–0.83	55.08	0.209	1.074	0.34	2012-06-07 11:21
7,416.40	2,385.82	–398.30	ÄSPÖ96	21.00	0.32	–0.80	55.17	0.209	1.074	0.39	2012-06-07 11:21
7,418.11	2,388.28	–398.34	ÄSPÖ96	24.00	0.36	–0.80	55.10	0.209	1.074	0.45	2012-06-07 11:21
7,419.83	2,390.74	–398.38	ÄSPÖ96	27.00	0.41	–0.80	55.04	0.209	1.074	0.51	2012-06-07 11:21
7,421.55	2,393.20	–398.42	ÄSPÖ96	30.00	0.45	–0.80	54.97	0.209	1.074	0.56	2012-06-07 11:21
7,423.27	2,395.65	–398.46	ÄSPÖ96	33.00	0.49	–0.80	54.97	0.209	1.074	0.62	2012-06-07 11:21
7,424.99	2,398.11	–398.50	ÄSPÖ96	36.00	0.53	–0.80	55.12	0.209	1.074	0.67	2012-06-07 11:21
7,426.71	2,400.57	–398.55	ÄSPÖ96	39.00	0.57	–0.80	55.07	0.209	1.074	0.73	2012-06-07 11:21
7,428.42	2,403.03	–398.59	ÄSPÖ96	42.00	0.62	–0.80	55.07	0.209	1.074	0.79	2012-06-07 11:21
7,430.14	2,405.49	–398.63	ÄSPÖ96	45.00	0.66	–0.80	55.07	0.209	1.074	0.84	2012-06-07 11:21
7,431.86	2,407.95	–398.67	ÄSPÖ96	48.00	0.70	–0.80	55.02	0.209	1.074	0.90	2012-06-07 11:21
7,433.58	2,410.41	–398.71	ÄSPÖ96	51.00	0.74	–0.80	54.97	0.209	1.074	0.96	2012-06-07 11:21
7,435.31	2,412.86	–398.76	ÄSPÖ96	54.00	0.78	–0.80	54.85	0.209	1.074	1.01	2012-06-07 11:21
7,437.03	2,415.31	–398.80	ÄSPÖ96	57.00	0.83	–0.80	54.80	0.209	1.074	1.07	2012-06-07 11:21
7,438.76	2,417.76	–398.84	ÄSPÖ96	60.00	0.86	–0.72	54.74	0.209	1.074	1.12	2012-06-07 11:21
7,440.50	2,420.21	–398.88	ÄSPÖ96	63.00	0.90	–0.71	54.74	0.209	1.074	1.18	2012-06-07 11:21
7,442.23	2,422.66	–398.91	ÄSPÖ96	66.00	0.94	–0.72	54.79	0.209	1.074	1.24	2012-06-07 11:21
7,443.96	2,425.11	–398.95	ÄSPÖ96	69.00	0.98	–0.71	54.69	0.209	1.074	1.29	2012-06-07 11:21
7,445.69	2,427.56	–398.99	ÄSPÖ96	72.00	1.01	–0.71	54.69	0.209	1.074	1.35	2012-06-07 11:21
7,447.42	2,430.01	–399.02	ÄSPÖ96	75.00	1.05	–0.69	54.85	0.209	1.074	1.41	2012-06-07 11:21
7,449.15	2,432.46	–399.06	ÄSPÖ96	78.00	1.09	–0.67	54.85	0.209	1.074	1.46	2012-06-07 11:21

Northing (m)	Easting (m)	Elevation (m)	Coordinate System	Length (m)	Vertical Depth (m)	Inclination (degrees)	Bearing (degrees)	Inclination Uncertainty	Bearing Uncertainty	Radius Uncertainty	Calc Date
7,450.88	2,434.92	–399.09	ÄSPÖ96	81.00	1.12	–0.65	54.85	0.209	1.074	1.52	2012-06-07 11:21
7,452.61	2,437.37	–399.13	ÄSPÖ96	84.00	1.15	–0.61	54.67	0.209	1.074	1.57	2012-06-07 11:21
7,454.34	2,439.81	–399.16	ÄSPÖ96	87.00	1.19	–0.61	54.67	0.209	1.074	1.63	2012-06-07 11:21
7,456.08	2,442.26	–399.19	ÄSPÖ96	90.00	1.22	–0.60	54.63	0.209	1.074	1.69	2012-06-07 11:21
7,457.81	2,444.71	–399.22	ÄSPÖ96	93.00	1.25	–0.60	55.02	0.209	1.074	1.74	2012-06-07 11:21
7,459.53	2,447.17	–399.25	ÄSPÖ96	96.00	1.28	–0.59	55.07	0.209	1.074	1.80	2012-06-07 11:21
7,461.24	2,449.63	–399.28	ÄSPÖ96	99.00	1.31	–0.59	55.07	0.209	1.074	1.86	2012-06-07 11:21
7,461.90	2,450.57	–399.30	ÄSPÖ96	100.15	1.32	–0.59	55.07	0.209	1.074	1.88	2012-06-07 11:21

Number of rows: 35. Printout from Sicada 2012-11-14 13:20:39.

Appendix 13

In-data: Borehole deviation data for KA3065A01

Sicada – Coordinate Information for KA3065A01 (Object type: Cored borehole)

Northing (m)	Easting (m)	Elevati (m)	on Coordinate System	Length (m)	Vertical Depth (m)	Inclination (degrees)	Bearing (degrees)	Inclination Uncertainty	Bearing Uncertainty	Radius Uncertainty	Calc Date
7,348.01	2,389.47	–406.65	ÄSPÖ96	0.00	0.00	–0.65	55.35	0.049	0.455	0.00	2012-06-07 11:21
7,349.72	2,391.94	–406.69	ÄSPÖ96	3.00	0.04	–0.72	55.26	0.049	0.455	0.02	2012-06-07 11:21
7,351.43	2,394.40	–406.73	ÄSPÖ96	6.00	0.07	–0.71	55.35	0.049	0.455	0.05	2012-06-07 11:21
7,353.12	2,396.88	–406.76	ÄSPÖ96	9.00	0.11	–0.67	55.75	0.049	0.455	0.07	2012-06-07 11:21
7,354.80	2,399.36	–406.80	ÄSPÖ96	12.00	0.14	–0.66	56.21	0.049	0.455	0.10	2012-06-07 11:21
7,356.47	2,401.85	–406.83	ÄSPÖ96	15.00	0.18	–0.66	55.95	0.049	0.455	0.12	2012-06-07 11:21
7,358.16	2,404.33	–406.87	ÄSPÖ96	18.00	0.21	–0.64	55.53	0.049	0.455	0.14	2012-06-07 11:21
7,359.86	2,406.80	–406.90	ÄSPÖ96	21.00	0.25	–0.63	55.42	0.049	0.455	0.17	2012-06-07 11:21
7,361.57	2,409.27	–406.93	ÄSPÖ96	24.00	0.28	–0.61	55.28	0.049	0.455	0.19	2012-06-07 11:21
7,363.29	2,411.73	–406.96	ÄSPÖ96	27.00	0.31	–0.60	54.85	0.049	0.455	0.21	2012-06-07 11:21
7,365.01	2,414.19	–407.00	ÄSPÖ96	30.00	0.34	–0.57	54.99	0.049	0.455	0.24	2012-06-07 11:21
7,366.72	2,416.65	–407.02	ÄSPÖ96	33.00	0.37	–0.54	55.56	0.049	0.455	0.26	2012-06-07 11:21
7,368.41	2,419.13	–407.05	ÄSPÖ96	36.00	0.40	–0.47	55.70	0.049	0.455	0.29	2012-06-07 11:21
7,370.11	2,421.60	–407.08	ÄSPÖ96	39.00	0.42	–0.46	55.61	0.049	0.455	0.31	2012-06-07 11:21
7,371.80	2,424.08	–407.10	ÄSPÖ96	42.00	0.44	–0.44	55.59	0.049	0.455	0.33	2012-06-07 11:21
7,373.49	2,426.56	–407.12	ÄSPÖ96	45.00	0.47	–0.42	55.65	0.049	0.455	0.36	2012-06-07 11:21
7,375.19	2,429.03	–407.14	ÄSPÖ96	48.00	0.49	–0.36	55.65	0.049	0.455	0.38	2012-06-07 11:21
7,376.88	2,431.51	–407.16	ÄSPÖ96	51.00	0.51	–0.35	55.72	0.049	0.455	0.40	2012-06-07 11:21
7,378.58	2,433.98	–407.18	ÄSPÖ96	54.00	0.52	–0.33	55.05	0.049	0.455	0.43	2012-06-07 11:21
7,380.30	2,436.44	–407.20	ÄSPÖ96	57.00	0.54	–0.30	55.19	0.049	0.455	0.45	2012-06-07 11:21
7,382.01	2,438.90	–407.21	ÄSPÖ96	60.00	0.56	–0.27	55.16	0.049	0.455	0.48	2012-06-07 11:21
7,383.72	2,441.37	–407.22	ÄSPÖ96	63.00	0.57	–0.25	55.36	0.049	0.455	0.50	2012-06-07 11:21
7,385.43	2,443.84	–407.24	ÄSPÖ96	66.00	0.58	–0.23	55.33	0.049	0.455	0.52	2012-06-07 11:21
7,387.13	2,446.30	–407.25	ÄSPÖ96	69.00	0.59	–0.21	55.24	0.049	0.455	0.55	2012-06-07 11:21
7,388.85	2,448.77	–407.26	ÄSPÖ96	72.00	0.60	–0.18	55.22	0.049	0.455	0.57	2012-06-07 11:21
7,390.56	2,451.23	–407.27	ÄSPÖ96	75.00	0.61	–0.17	55.22	0.049	0.455	0.60	2012-06-07 11:21
7,392.27	2,453.70	–407.28	ÄSPÖ96	78.00	0.62	–0.16	55.32	0.049	0.455	0.62	2012-06-07 11:21

Northing (m)	Easting (m)	Elevati (m)	on Coordinate System	Length (m)	Vertical Depth (m)	Inclination (degrees)	Bearing (degrees)	Inclination Uncertainty	Bearing Uncertainty	Radius Uncertainty	Calc Date
7,393.97	2,456.16	–407.28	ÄSPÖ96	81.00	0.63	–0.15	55.25	0.049	0.455	0.64	2012-06-07 11:21
7,395.68	2,458.63	–407.29	ÄSPÖ96	84.00	0.64	–0.14	55.35	0.049	0.455	0.67	2012-06-07 11:21
7,397.39	2,461.10	–407.30	ÄSPÖ96	87.00	0.64	–0.15	55.35	0.049	0.455	0.69	2012-06-07 11:21
7,399.09	2,463.56	–407.31	ÄSPÖ96	90.00	0.65	–0.15	55.35	0.049	0.455	0.71	2012-06-07 11:21
7,400.80	2,466.03	–407.31	ÄSPÖ96	93.00	0.66	–0.12	55.20	0.049	0.455	0.74	2012-06-07 11:21
7,402.52	2,468.49	–407.32	ÄSPÖ96	96.00	0.66	–0.10	54.91	0.049	0.455	0.76	2012-06-07 11:21
7,404.24	2,470.94	–407.32	ÄSPÖ96	99.00	0.67	–0.10	54.87	0.049	0.455	0.79	2012-06-07 11:21
7,405.97	2,473.40	–407.33	ÄSPÖ96	102.00	0.67	–0.10	54.82	0.049	0.455	0.81	2012-06-07 11:21
7,407.70	2,475.85	–407.33	ÄSPÖ96	105.00	0.68	–0.09	54.82	0.049	0.455	0.83	2012-06-07 11:21
7,409.43	2,478.30	–407.34	ÄSPÖ96	108.00	0.68	–0.09	55.00	0.049	0.455	0.86	2012-06-07 11:21
7,411.14	2,480.76	–407.34	ÄSPÖ96	111.00	0.69	–0.08	55.16	0.049	0.455	0.88	2012-06-07 11:21
7,412.86	2,483.23	–407.35	ÄSPÖ96	114.00	0.69	–0.07	55.16	0.049	0.455	0.91	2012-06-07 11:21
7,414.57	2,485.69	–407.35	ÄSPÖ96	117.00	0.70	–0.08	55.16	0.049	0.455	0.93	2012-06-07 11:21
7,416.29	2,488.15	–407.36	ÄSPÖ96	120.00	0.70	–0.11	54.86	0.049	0.455	0.95	2012-06-07 11:21
7,418.02	2,490.60	–407.36	ÄSPÖ96	123.00	0.71	–0.11	54.80	0.049	0.455	0.98	2012-06-07 11:21
7,419.32	2,492.44	–407.37	ÄSPÖ96	125.25	0.71	–0.11	54.80	0.049	0.455	0.99	2012-06-07 11:21

Number of rows: 43.

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