Report
P-15-14
December 2016

KBS-3H

Boremap mapping of borehole K08028F01

Oskar Sigurdsson

SVENSK KÄRNBRÄNSLEHANTERING AB

SWEDISH NUCLEAR FUEL
AND WASTE MANAGEMENT CO

Box 250, SE-101 24 Stockholm
Phone +46 8 459 84 00
skb.se

SVENSK KÄRNBRÄNSLEHANTERING

ISSN 1651-4416
SKB P-15-14
ID 1469220
December 2016

KBS-3H

Boremap mapping of borehole K08028F01

Oskar Sigurdsson, Oskar Sigurdsson Geological consulting

Keywords: Borehole, Logging, Boremap, OPTV, Geology, Bedrock, Fractures.

This report concerns a study which was conducted for Svensk Kärnbränslehantering AB (SKB). The conclusions and viewpoints presented in the report are those of the author. SKB may draw modified conclusions, based on additional literature sources and/or expert opinions.

Data in SKB's database can be changed for different reasons. Minor changes in SKB's database will not necessarily result in a revised report. Data revisions may also be presented as supplements, available at www.skb.se.

A pdf version of this document can be downloaded from www.skb.se.

Abstract

The borehole K08028F01 was core drilled in the Äspö Hard Rock Laboratory (Äspö HRL) in 2014 as the first step of the sub-project KBS-3H Sub System Demonstration, 2011–2016.

The result from the Boremap mapping of the borehole is presented in this report. The starting position of the borehole was at the end of the TAS08 tunnel and has a length of 94.39 m, with bearing 320.37° and an upward inclination 2.18°.

The geological mapping was done according to the Boremap method, which is based on simultaneous study of drill core and borehole image (in this case OPTV).

The dominant rock type observed in the borehole is Ävrö granodiorite (rock code 501056) constituting approximately 50 % of the mapped interval while fine-medium grained Granite (rock code 511058) makes up approximately 36 %. The later rock type is also frequent as subordinate rock occurrences (< 1 m wide, dykes and/or veins) cutting other rock types throughout the length of the borehole. This also applies to Pegmatite (rock code 501061) which makes up approximately 3 % of the mapped rock volume. The third main rock type is fine-grained Diorite-gabbro (rock code 505102) making up approximately 9 % of the rock volume. Finally, porphyritic Äspö diorite (rock code 501037) appears to make up approximately 2 % of the borehole.

Alteration in the form of red staining (oxidation) occurs in approximately 50 % of the core and epidotization in approximately 20 %. The total number of mapped fractures is 560, divided into; broken fractures (3.1 fractures/metre), unbroken fractures (2.8 fractures/metre) and partly open fractures (approximately 0.2 fractures/metre). Thirteen sealed networks were mapped in the borehole as well as one crush.

Structural observations in the borehole include breccia, cataclastic structures, ductile shear zone, a mylonitic structure, banding and foliations.

The last approximately 20 m of the borehole show alteration, an increase in fracture frequency as well as foliated rock, indicating the presence of or proximity to a deformation zone.

The KBS-3H design has been developed jointly by SKB and Posiva since 2002. This report has been prepared within the project phase “KBS-3H – System Design 2011–2016”.

Sammanfattning

Kärnborrhålet K08028F01 borrades i Äspö laboratoriet 2014 som det första steget av delprojektet KBS-3H Sub-system demonstration.

Resultaten från Boremap-karteringen av borrhålet presenteras i denna rapport. Borrhålets påhugg är beläget i fronten av TAS08 och har en längd av 94,39 m från bergväggen, med riktning 320,37° och stupning 2,18°.

Den geologiska karteringen är gjord enligt Boremap metoden, som baseras på en kartering av kärna och borrhålsbild (OPTV).

Ävrö granodiorit (bergartskod 501056) är den dominerande bergarten i borrhålet och utgör ca 50 % av den, medan fin-medelkornig granit (bergartskod 511058) utgör ca 36 % av den karterade bergartsvolymen i borrkärnan, denna bergart förekommer även som gångar och/eller ådror (<1 m breda) som klipper andra bergarter i borrhålet, liksom pegmatiter (bergartskod 501061) som utgör nära 3 % av den karterade bergartsvolymen i borrkärnan. Den tredje huvudbergarten är en finkornig diorit-gabbro (bergartskod 505102) som utgör ca 9 % av borrkärnans bergartsvolym. Till slut förekommer den porfyritiska Äspö dioriten (bergartskod 501037) som enbart verkar utgöra ca 2 % av bergartsvolymen i borrhålet.

Omvandling som rödfärgning (oxidering) förekommer i ca 50 % av kärnan och epidotisering i ca 20 %. Det totala antalet karterade sprickor är 560, som delas upp i brutna sprickor (3,1 sprickor/meter), obrutna sprickor (2,8 sprickor/meter) och delvis öppna sprickor (ca 0,2 sprickor/meter). Tretton spricknätverk med läkta sprickor samt en zon med kross karterades i borrhålet.

Strukturobservationer i borrhålet inkluderar breccia, kataklastiska strukturer, en plastisk skjuvzon, en mylonitisk struktur, bandning och foliering.

De sista ungefärligen 20 m av borrhålet visar omvandling, ökning i sprickfrekvens samt folierad berg, som skulle kunna indikera närhet till en deformation zon.

KBS-3H är en variant av KBS-3 metoden som utvecklas gemensamt av SKB och Posiva. Denna rapport har utarbetats under projektfasen ”KBS-3H – System Design 2011–2016.

Contents

1 Introduction

Borehole K08028F01 was core drilled in the Äspö Hard Rock Laboratory in 2014 as the first step of the KBS-3H Sub-Project plan Sub System Demonstration, 2011–2016. As described in the activity plan for the drilling c.f. Table 1-1, the drilling needs to fulfil the strict demands for the KBS-3H deposition alternative, i.e. an upward dip of 2° (± 1°) and that over each 6 m section of the borehole the deviation is no more than ± 10 mm vertically and ± 20 mm horizontally. The end-point of the borehole deviates less than 67 cm from the theoretical end point of the straight line from the borehole collar extending in the start direction. To answer up to these requirements directional drilling was employed.

The geological prognosis for the drilling of the borehole presented in the activity plan, c.f. Table 1-1, indicated that the borehole could intersect a possible deformational zone (DZ) after approximately 64 m.

After completed drilling the borehole was logged with both the OPTV and the BIPS systems and subsequently mapped according to the Boremap method, using the OPTV log, according to method description listed in Table 1-1. The current document reports data and results gained from the Boremap mapping of borehole K08028F01. The work was carried out in accordance with activity plan AP TD 3HDEMO-14-043 Boremap-kartering i K08028F01. Controlling documents for the execution of 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. These are internal unpublished SKB documents.

Activity plans	Number	Version
Boremapkartering i K08028F01 (Boremap logging in K08028F01)	AP TD 3HDEMO-14-043	1.0
Kärnborrning av K08028F01 (Cored drilling of K08028F01)	AP TD 3HDEMO-14-036	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för Boremapkartering (Method description for Boremap logging).	SKB MD 143.006	3.0
Mätsystembeskrivning – Allmänt Boremapkartering med Boremap version 4.1 (Description of the measuring system – General Boremap mapping with Boremap version 4.1)	SKB MD 146.005	2.0
Nomenklatur vid Boremapkartering (Boremap logging nomenclature)	SKB MD 143.008	1.0
Regler för bergarters benämningar för Laxemar-Simpevarpsområdet och för Äspölaboratoriet (Rules for rock names at the Laxemar-Simpevarp area and the Äspö Laboratory)	SKB MD 132.004	3.0

Table 1-2. The rock nomenclature (rock types and rock occurrences) used in the Boremap mapping.

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 monzodiorite to granodiorite, equigranular to sparsely porphyritic
Diorite-gabbro	501033	Diorite to gabbro
Fine-grained dioritoid	501030	Intermediate rock, fine-grained
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

The bearing, inclination and length of the borehole, as well as the identification tag of the tunnel that it was drilled from can be seen in Table 1-3. The location of the borehole K08028F01 can be seen in Figure 1-1, together with borehole K03009F01which earlier was drilled as a part of the subproject DETUM-1 Large fractures.

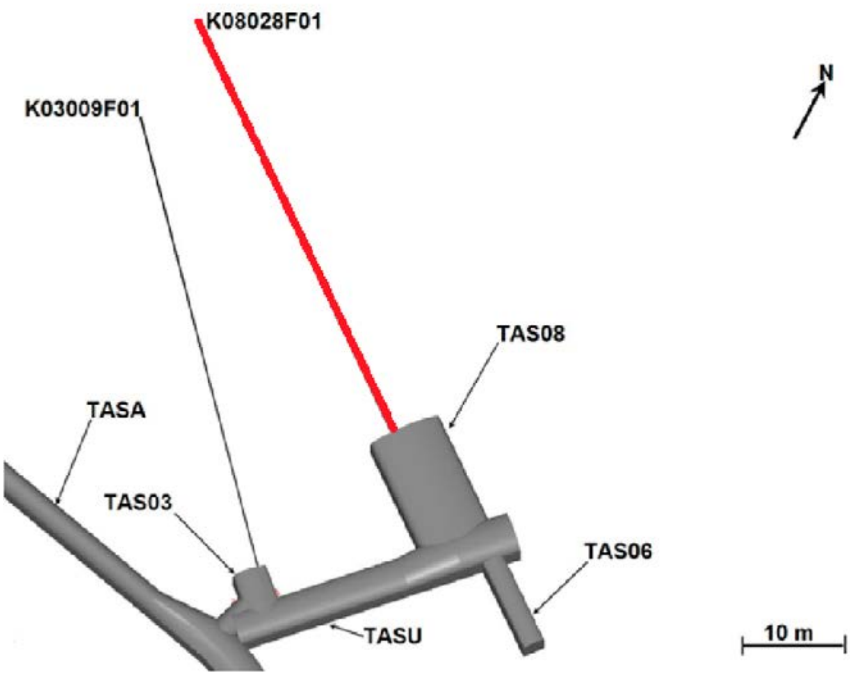


Figure 1-1. *The location of borehole K08028F01 in tunnel TAS08. The borehole K03009F01 as well as tunnels TASA, TASU, TAS06 and TAS08 is shown. The image presented in RVS is shown from above.*

Table 1-3. Bearing, inclination, length as well as tunnel ID where borehole K08028F01 was collared. The coordinate system of the bearing is the Äspö96 system.

	K08028F01
Bearing (ÄSPÖ 96)	320.37°
Inclination	2.18°
Length	94.39 m
Tunnel	TAS08

The KBS-3H design has been developed jointly by SKB and Posiva since 2002. This report has been prepared within the project phase "KBS-3H – System Design 2011–2016".

The Boremap mapping method is based on the combined information from detailed drill core logging and OPTV-image (Borehole optical televiewer probe) of the borehole wall. Petrographical (rock types, rock occurrences and alteration) and structural (fractures, crush and ductile deformation) information is obtained. In addition, the Boremap mapping software calculates the orientation (strike and dip) of each marked planar feature in the borehole using information from the OPTV-imaging and borehole surveying. Aperture and widths of fractures are estimated according to the definitions of Boremap mapping (in the method descriptions, listed in Table 1-1), where width is the aperture plus eventual visible fracture filling measured across a fracture. The roughness of broken (open) fracture surfaces (ISRM 1978) is estimated as well. In addition, all identified minerals identified on a fracture surface are listed.

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

2 Objective and scope

The aim of the activity presented in this report is to document, by using the Boremap mapping method, all macroscopic lithologies and their alteration as well as fractures, crush and zones of ductile deformation intersecting the borehole K08028F01.

3 Equipment

3.1 Description of software

Mapping of drill core with OPTV-images according to the Boremap method is done on a desktop computer using the software Boremap (version 5.1.0.0), which shows the video image from OPTV (the Borehole optical televiewer probe) and extracts the geometrical parameters: length, width, strike and dip from the image, see Figure 3-1.

The rock type, rock occurrence, structural and fracture data are entered in a form that appears on the right side of the OPTV-image on the computer screen, this data is collected in a spreadsheet at the bottom of the screen, see Figure 3-1.

The length registered in the OPTV-image is adjusted using the core length of easily recognisable structures in both core and OPTV-images. The diameter and orientation (bearing and inclination) of the borehole is the basis for calculating the strike and dip of the mapped planar structures. Data from deviation measurements (Devico PeeWee and Reflex gyro) are imported from Sicada and used by the Boremap software to correct for changes in direction of the boreholes with length.

The final data presentation was made using OPTV Image Print, Dips (version 5.1), Microsoft Access, Microsoft Excel and WellCAD (version 4.2).

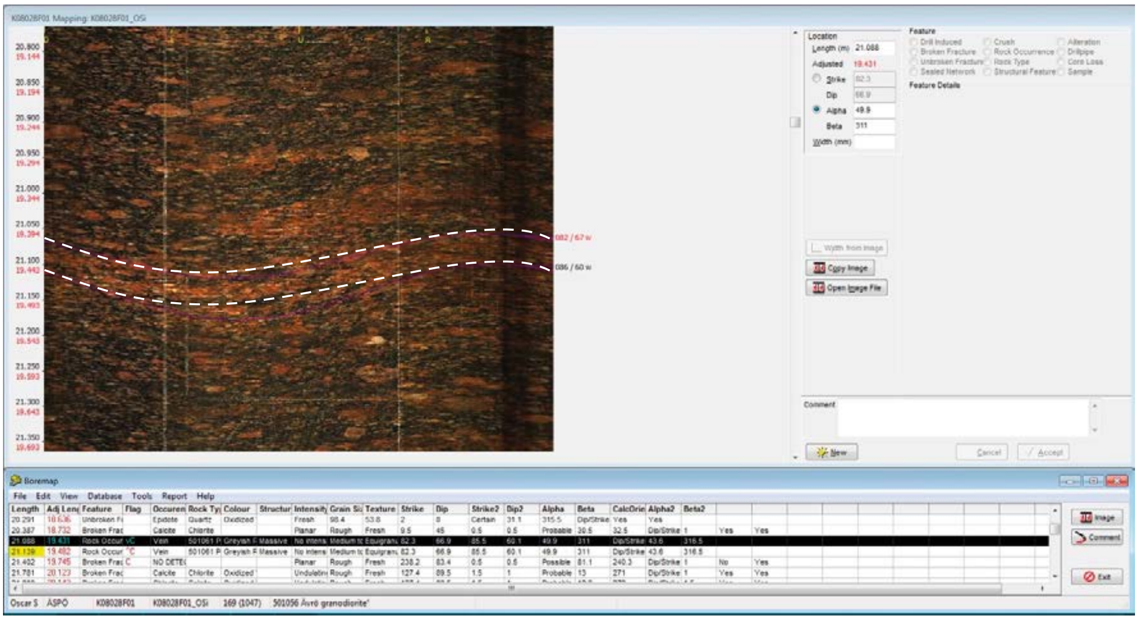


Figure 3-1. *A good-acceptable quality OPTV-image as it is seen in the Boremap software. Borehole K08028F01, length 19.1–19.7 m adjusted length (red numbers), showing grey (to slightly reddish grey), medium grained, massive (to slightly deformed/foliated) and evenly grained (with occasional porphyroblasts) Ävrö granodiorite, cut by a thin and somewhat irregular Pegmatite vein. The white dashed lines mark the upper and lower contacts of the pegmatite vein and on the right side of the image the strike and dip of each contact is shown. Data on the rock occurrence are in the database spreadsheet at the bottom of the image, with the upper contact highlighted.*

3.2 Other equipment

For the mapping of the core the following geological field equipment was used; a folding ruler, water-filled atomizer, hand held lens, streak plate (a piece of white, unglazed porcelain), small magnet, hydrochloric acid (HCl 10 % solution), knife and pencil. When needed, a Zeiss Stemi DV4 (magnification 8X-32X) stereomicroscope is available for studying minor fracture fillings, as well as a Susceptibility meter (SM20 from GF instruments) to measure the magnetic susceptibility of the rock types in the drill core.

3.3 OPTV-image video film sequences

The OPTV imaging of the K08028F01 core covers the interval between 2.5–93.51 m (adjusted length) as well as the interval between 0.24–2.13 m (adjusted length).

3.4 OPTV-image video film quality

The quality of the OPTV-image depends on several parameters:

- The absence of borehole water (i.e. the glittering of wet borehole walls in the camera light).
- The condition of the borehole walls (e.g. the amount of sedimentation and/or gauge on the borehole wall).
- The quality of the OPTV-image (i.e. the technical limitations of the imaging; resolution and contrast).

3.4.1 OPTV-image resolution

The acquisition setting of the OPTV is set at the resolution 720p. The image is then kept at optimum by adjusting the light, exposure and the speed of the camera (in m/min) depending on the conditions in the borehole (e.g. dark or light coloured rock types).

3.4.2 OPTV-image contrast

The colour contrast between fractures and wall rock is important when visibility of fractures is discussed. A thin fracture in a dark rock can be seen in the OPTV-image if it is light in colour giving a high contrast. If the colour of the fracture is about the same as the colour of the rock the fracture cannot be observed due to absence of contrast.

3.4.3 OPTV-image quality

Generally, the image quality is divided into four classes:

- Good – the image is mainly clear and easy to interpret.
- Acceptable – the mapping can be performed without problems.
- Bad – image is somewhat difficult to interpret.
- Very bad – image cannot be interpreted and only very obvious and outstanding features can be mapped.

It should be remembered that even if only 10–20 % of the image is visible it is normally enough for an acceptable interpretation. When the OPTV-image quality is so bad that fractures and structures cannot be identified in the OPTV-image, they can still be oriented using the guide-line method (Section 4.3.3).

The quality of the OPTV-image for borehole K08028F01 is generally good. The variations that do occur are:

- Scratches on the borehole walls, probably from the drill rods and/or drill bit (see Figure 5-2 and 5-3).
- A somewhat dark image, which is a compromise between the light scratches and glittering of the wet walls of the borehole compared to the generally dark grey to greyish red colour of the rock types.

The OPTV-image quality for K08028F01 is presented in Table 3-1.

Table 3-1. OPTV-image quality of borehole K08028F01 (lengths are adjusted). Casing covers the uppermost 2.2 m of the borehole.

Sec Up (m)	Sec Low (m)	Interval (m)	Quality
0.240	2.147	1.907	Good-acceptable
2.249	93.51	91.261	Good-acceptable

4 Execution

4.1 General

The Boremap-OPTV mapping of the core drilled borehole K08028F01 was performed and documented in accordance with activity plan AP TD 3HDEMO-14-043 (SKB internal document). The mapping was performed in accordance with the current SKB method descriptions, as listed in Table 1-1.

The drill core was displayed on inclined roller tables in its entire length and mapped with the Boremap system at the SKB core-logging facility in Oskarshamn. The core mapping was compared to preliminary results from geophysical logs.

4.2 Preparations

The length of the borehole registered in the OPTV-image is adjusted to the true length in the borehole by noting the length marked on the core to clearly visible rock contacts in the borehole as well as other clearly recognizable features in both OPTV-image and core, e.g. the lower end of the casing at 2.2 m, and rock occurrences close to the end of each of the two directional borings at 66.94 m and 74.05 m, where the contact of a fine-grained granite at 65.652 m and the contact of a pegmatite vein at 73.302 m were used respectively. The different relative orientations of the observations made on the core/imaging were recalculated to true geometries in 3D space. Data necessary for this calculations are borehole bearing, inclination, diameter, length and deviation, all extracted from the Sicada database.

4.3 Execution of measurements

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

The first approximately 2.28 m of borehole K08028F01 has casing with a separate OPTV-image of the borehole walls down to approximately 2.13 m. At the bottom of the borehole approximately 0.88 m of the borehole is without OPTV-image due to the limitations of the probe. See Table 4-1 for lengths of core and OPTV image.

The lengths of core as compared to the OPTV-image are corrected using the difference of core diameter between the directional drilling (31.5 mm) and the conventional (50.2 mm), assuming that the most correct lengths come from the drilling rods when the directional drilling stops and the conventional drilling starts again.

Table 4-1. Lengths of core and core diameter as well as lengths of OPTV-image with measured lengths and adjusted lengths, of borehole K08028F01. Directional drilling yields a core of a smaller diameter than normal drilling.

	K08028F01 (m)
Core with diameter 0.10 m	0–2.28
Core with diameter 0.05 m	2.28–64.86 66.04–72.78 74.05–94.39
Core with diameter 0.03 m	64.86–66.04 72.78–74.05
OPTV image measured length OPTV image adjusted length	0.2–2.05 0.24–2.147
OPTV image measured length OPTV image adjusted length	2.9–95.35 2.249–93.51

The borehole lengths that are not OPTV-logged can still be mapped with the Boremap system. But, devoid of OPTV-imaging, orientations for planar structures can only be obtained if the core outside the OPTV-image can be reassembled with the oriented part of the core. This is the case for the K08028F01, at least for the concluding approximately 0.88 m mapped according to the guide-line method (see Chapter 4.3.3).

4.3.1 Fracture definitions

Definition of different fracture types (broken and unbroken) as well as crush and sealed fracture networks can be found in SKB MD 143.006 "Metodbeskrivning för Boremap-kartering" (Method description for Boremap mapping) and SKB MD 143.008 "Nomenklatur vid Boremap-kartering" (Boremap logging nomenclature), see Table 1-1 and Table 1-2.

Fractures are mapped as broken if they split the core and unbroken if they do not. All fractures are described according to width, mineral fillings and alteration. Fracture width is defined as possible aperture plus possible fracture-filling measured across the fracture. Alteration, when present, is measured in the same way and includes the width. Broken fractures have in addition been assigned the attributes roughness and surface. The resolution of the OPTV-images allows fractures down to 1 mm thick to be measured in the images. Thinner fractures are denoted a value of 0.5 mm. The same principle is used for measuring apertures of broken fractures, the reliability or confidence in aperture quantification is estimated according to the following:

- Certain – aperture is visible in OPTV-image and measurable to 1 mm or larger.
- Probable – core bits do not fit perfectly, aperture is given the value 0.5 mm.
- Possible – altered fracture surface, aperture is given the value 0.5 mm.

Unbroken fractures that have visible apertures are categorised as being partly open fractures.

Cataclastic structures that show a thickness (width) of approximately 10 mm or more are here mapped as structural entities within the Boremap parameter rock occurrence, which has an upper and lower contact. Usually these rock occurrences are dominated by green epidote matrix with various amounts of clasts, normally consisting of the same rock as the designated rock occurrence. Strike and dip of the cataclastic structure is obtained by regarding it as a structural parameter within the rock occurrence.

4.3.2 Fracture alteration and joint alteration number

The joint alteration number for a fracture is mainly related to the width of the mineral fillings and their clay content. Thicker fractures rich in clay minerals are assigned joint alteration numbers 2–3, while the majority of fractures which are very thin to extremely thin seldom contain clay minerals and receive joint alteration numbers between 1 and 2.

- Joint alteration 1 – Fractures without wall rock alterations and with no mineral fillings are considered fresh. The same goes for fractures that have wall rock alteration of e.g. oxidation (red colouring) or epidotization. The fracture filling minerals calcite, quartz, fluorite, zeolites (e.g. laumontite) and sulphides are considered to be deposited in broken fractures by circulating water-rich solutions and are not fracture alteration minerals. The joint alteration number is therefore set to 1 for these minerals.
- Joint alteration 1.5 – The fracture filling minerals epidote, prehnite, hematite, chlorite and/or clay minerals are considered to be mainly resulting from altered wall rock material. A weak alteration is thus assumed and the joint alteration number is set to 1.5. The thickness of the clay minerals is important since their occurrence often results in a higher joint alteration number.
- Joint alteration > 1.5 – If fracture filling minerals are a few mm wide bands 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-rich bands, together with e.g. chlorite, the joint alteration number is set to 3.

4.3.3 Mapping of fractures not visible in the OPTV imaging

Fractures that are not visible in the OPTV-image are orientated by using the guide-line method (Ehrenborg and Dahlin 2005), based on the following data:

- Adjusted borehole length (depth).
- Amplitude (the interval from the uppermost to the lowermost extreme of a fracture measured along the drill core).
- The relation between the orientations of the fracture trace measured on the drill core and a well-defined structure that is visible in both the OPTV-image and drill core.

The error in fracture orientations using the guide line method is unknown, but estimated to be negligible. It is considered better than the alternative, which is to mark all fractures not visible in the OPTV-image as planes perpendicular to the borehole axis. All fractures are marked as either visible in OPTV or not in the Boremap mapping, which makes it possible to separate the two.

Correction for the difference between the core and borehole wall diameter are made for each fracture, as the OPTV-image represents the borehole wall, which is larger in diameter than the core. The difference in adjusted borehole length between core and borehole wall is zero for structures that cut the core at right angles. This difference increases as the orientation of the structure approximates the core axis.

The following steps describe mapping of structures with the guide line method:

- The structure is drawn on the OPTV-image as a structure trace (e.g. the white dashed lines in Figure 3-1) and the amplitude of the structure in the core is corrected to the higher value in the OPTV-image.
- The structure trace is rotated in the OPTV-image to the correct position relative to a feature with known orientation (strike and dip).
- The structure trace is moved to the adjusted length in the OPTV-image, in accordance with the length measured on the drill core.

4.3.4 Definition of veins and dykes

Rock occurrences that have a true thickness less than 20 cm are defined as veins, while those varying between 20 and 100 cm are called dykes.

4.3.5 Fracture fillings and mineral codes

Fracture fillings are noted in order of decreasing abundance; if there are more than four minerals identified they are noted in the comment field. The identification and abundance of each mineral is subjective and is decided by ocular observation, which could result in possible misrepresentation of certain minerals depending on their visibility and distribution in the fracture as well as whether the fracture is broken or unbroken.

When mineral fillings that are not represented in the mineral list of Boremap occur in the drill core they are represented with an X and explanation in the comment field. No such mineral fillings occur in borehole K08028F01.

4.3.6 Alteration intensity and intensity of structural type

The intensity of the alteration is estimated and varies from fresh to completely altered rock, where all the original minerals have been altered to secondary minerals. In this report intensities of oxidation (red colouring) vary from weak to medium, while epidotization has been mapped only as weak:

- Faint: very weakly developed alteration, e.g. in the case of oxidation a slight red colouring of some mineral grains in an otherwise grey rock, and in the case of epidotization occasional mineral grains show green colouring.

- Weak: clearly developed alteration, e.g. in the case of oxidation most of the mineral grains in the rock show red colouring and in the case of epidotization most mineral grains show green colouring.
- Medium: strongly developed alteration, e.g. in the case of oxidation the rock has a strong red colour and in the case of epidotization the rock seems dominated by secondary minerals and has become greyish green in colour.
- Strong: very strongly developed alteration, e.g. in the case of epidotization the whole rock seems to be made up of secondary minerals, usually mostly epidote and chlorite.

Structural intensity varies somewhat depending on the type of structure, but in general the estimations within marked areas containing the mapped structures foliation and/or ductile zones are made as follows:

- Faint: weakly developed structure, usually some parallel orientation of mineral grains.
- Weak: clearly developed structure, usually as parallel orientation of many or most of the mineral grains.
- Medium: strongly developed structure, most of the mineral grains very clearly show parallel orientation.
- Strong: very strong developed structure, all mineral grains show very strong parallel orientation.

Banding occurs in borehole K08028F01 with the intensity marked as faint, meaning that the bands are poorly developed. The mylonite noted in K08028F01 is marked as weak, meaning that the structure is not a fully developed mylonite, the original mineral grains are still visible. The cataclastic structures in the borehole are all designated medium, meaning that they occur as bands with epidote dominated matrix and some fragments of the surrounding rock.

4.4 Data management

The Boremap mapping is performed on a desktop computer connected to the SKB computer network at SKB's core storage facility in Oskarshamn. Before every break (> 15 minutes) a back-up is saved on the local disk, as well as at the end of each day after being checked by the responsible mapping geologist.

The mapping is also checked by a computer routine in the Boremap program before it is exported to and archived in the Sicada database. Personnel from SKB also perform spot test controls and regular quality revisions.

All primary data are stored in SKB's database Sicada. Only these data are to be used for further interpretation and modelling.

5 Results

Below is a short summary of the results from the Boremap mapping for borehole K08028F01. More general information can be found in the Appendices A1.1–A1.4. WellCAD diagrams are shown in Appendix A1.1. OPTV-images of K08028F01 are shown in Appendix A1.2, BIPS-images of K08028F01 is presented in Appendix A1.3 and stereonets of all logged fractures, all broken fractures, all unbroken fractures, all partly broken fractures, sealed networks and cataclastic structures are shown in Appendix A1.4.

Some screen dumps from the core logging using the Boremap software with OPTV image are shown in Figures 5-1 through 5-9. The percentages of different lithologies are given in Table 5-1.

Various portions of the rock show red staining (oxidation) as well as green staining (epidotization). Table 5-2 shows the distribution as well as the intensity of the staining. In this Boremap mapping the alteration intensity was defined as weak when red- and/or green- staining was clear but did not dominate the original rock colour in the core. The alteration intensity was defined as medium when the red-staining was dominating the original rock colour in the core.

Table 5-3 shows the number of mapped fractures in the borehole (broken, unbroken and partly broken fractures) as well as the average fracture frequency per metre. Only one crush is mapped from the core and OPTV-image and is shown in Table 5-5. There the borehole length to the upper contact, width of the crush, the average rock piece length and the strike and dip of the upper contact is listed.

Table 5-3 shows the number of sealed networks mapped in the borehole, along with the average width and orientation of the upper contact.

Table 5-6 lists the number and direction of cataclastic structures mapped in the borehole. Also the average width of the rock occurrence that contains the cataclastic structure parameter is given as well as the average strike and dip of the designated cataclastic structure within each rock occurrence containing the cataclastic structure.

Tables 5-7 to 5-9 list the remaining mapped structures of the borehole. They are divided into, ductile shear zone, mylonite, breccia, banding and foliation. Their total number, intensity, average widths and average directions are also indicated.

The last approximately 20 m of the borehole show alteration, an increase in fracture frequency as well as foliated rock, indicating the presence of or proximity to a deformation zone (see Appendix A1.1).

Results from geophysical measurements made in boreholes K08028F01 were only tentatively used as support to the Boremap mapping of the core, as the results at that time were still only of preliminary nature. It is difficult to see any clear difference in density between Ävrö granodiorite and Äspö diorite in the logging, while the silicate density logs generally show more distinctly higher values for the fine-grained diorite-gabbro and lower values for the fine-medium grained granite. These mafic rock types are usually also somewhat lower in magnetic susceptibility, which is also the case for the fine-grained granites occurring in the borehole. Natural gamma radiation is generally somewhat higher in the fine-grained granites.

5.1 Lithology

The dominant rock type is Ävrö granodiorite, occasionally somewhat porphyritic. Other dominating rock types are fine-grained granite, fine-grained diorite-gabbro and Äspö diorite. All rock types are cut by the fine-grained granite as well as minor dykes and veins consisting of both fine-grained granite and pegmatites, see Figures 3-1 and 5-1, Table 5-1 and Appendix A1.1.

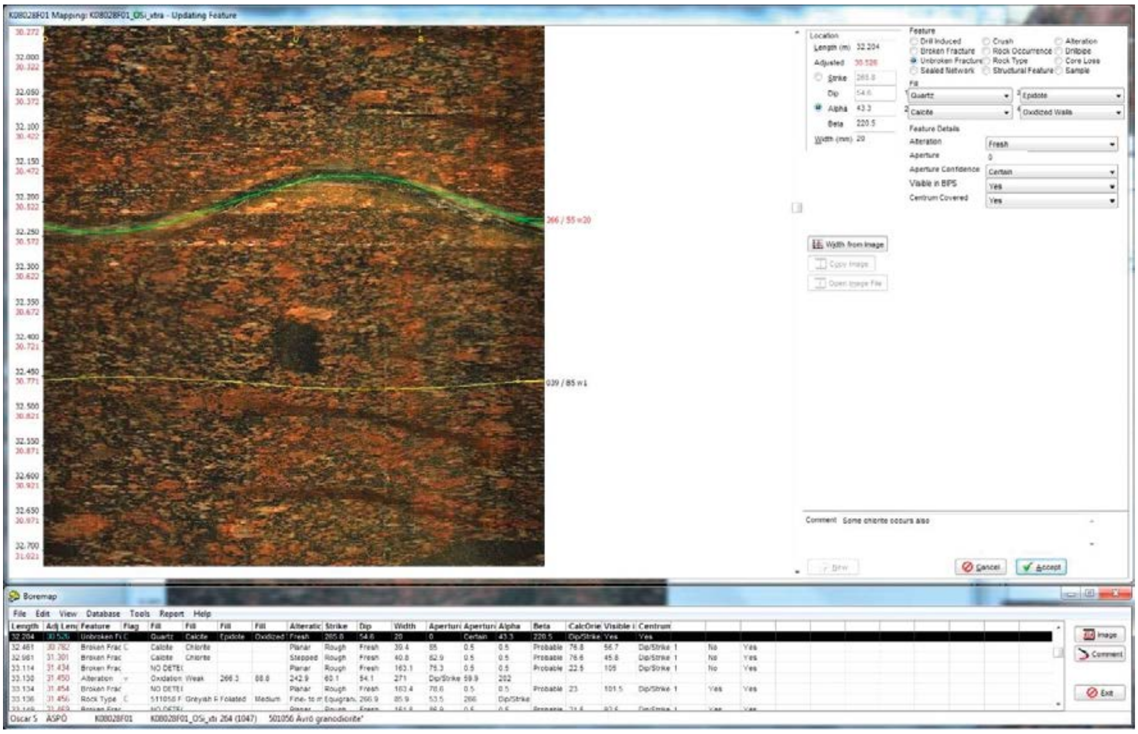


Figure 5-1. *A good quality OPTV-image as it is seen in the Boremap software. Borehole K08028F01, 30.272–31.021 m adjusted length (red numbers), showing light reddish grey, medium grained, foliated and equigranular Ävrö granodiorite, containing two fractures. The green line is logged by the geologist as a fresh, unbroken fracture filled with Quartz, Calcite, Epidote and with Oxidized walls. The comment field notes that some Chlorite also occurs. The yellow line is on the other hand logged as a planar, rough and fresh broken fracture filled with Calcite and Chlorite. The comment field here notes that the fracture may be broken as a consequence of an uptake of core at 30.84 m.*

Table 5-1. Lithology of K08028F01, rock types and rock occurrences. Percentage distribution calculated from adjusted length of OPTV-image (L= 0.231 − 94.39 m).

Rock name	SKB rock code	%
Ävrö granodiorite	501056	49.78
Äspö diorite	501037	2.17
Fine-grained granite	511058	35.78
Pegmatite	501061	3.21
Fine-grained diorite-gabbro	505102	9.06

5.2 Alteration

Alteration in the form of red staining (oxidation) occurs in 49.9 % of the core (49.1 % is weak and approximately 0.8 % is of medium intensity) and almost 20 % of the mapped core shows weak epidotization. The red staining (oxidation) is unevenly spread over the whole borehole while the epidotization occurs mainly in the last approximately 20 m of the borehole (see Figure 5-2, Table 5-2 and Appendix A1.1).

Table 5-2. Alteration in borehole K08028F01. Percentage distribution calculated from adjusted lengths of mapped oxidation or epidotization relative to total length of mapped core.

Alteration	Intensity	K08028F01 (total length) (%)
Oxidation	Weak	49.11
	Medium	0.79
Epidotization	Weak	19.87

5.3 Fractures

The total number of mapped fractures is 569, which can be subdivided into 292 broken fractures (average of 3.1 per metre) and 277 unbroken fractures (average of 2.9 per metre). Part of the unbroken fractures show aperture (partly open), the resulting numbers are 263 unbroken fractures (2.8 per metre) and 14 partly open fractures (approximately 0.1 per meter) see Table 5-3.The mapped fractures from the initial 1.85 m of core with a larger diameter (see Table 4-1) yielded 4 broken fractures with an average of 2.2 fractures/metre, unbroken fractures were 5 with 2.7 fractures per metre on average, no partly open fractures were mapped in the first 2.3 m of the borehole (Table 5-3).The total number of mapped fractures in the core below the casing is 560 fractures, with an average of 6.1 fractures per metre. Fourteen of those fractures did not cut the centre axis of the core (one broken fracture, eleven unbroken and two partly broken fractures) they are included in the stereograms in Appendix A1.4 having an assigned strike/dip = 0/0.

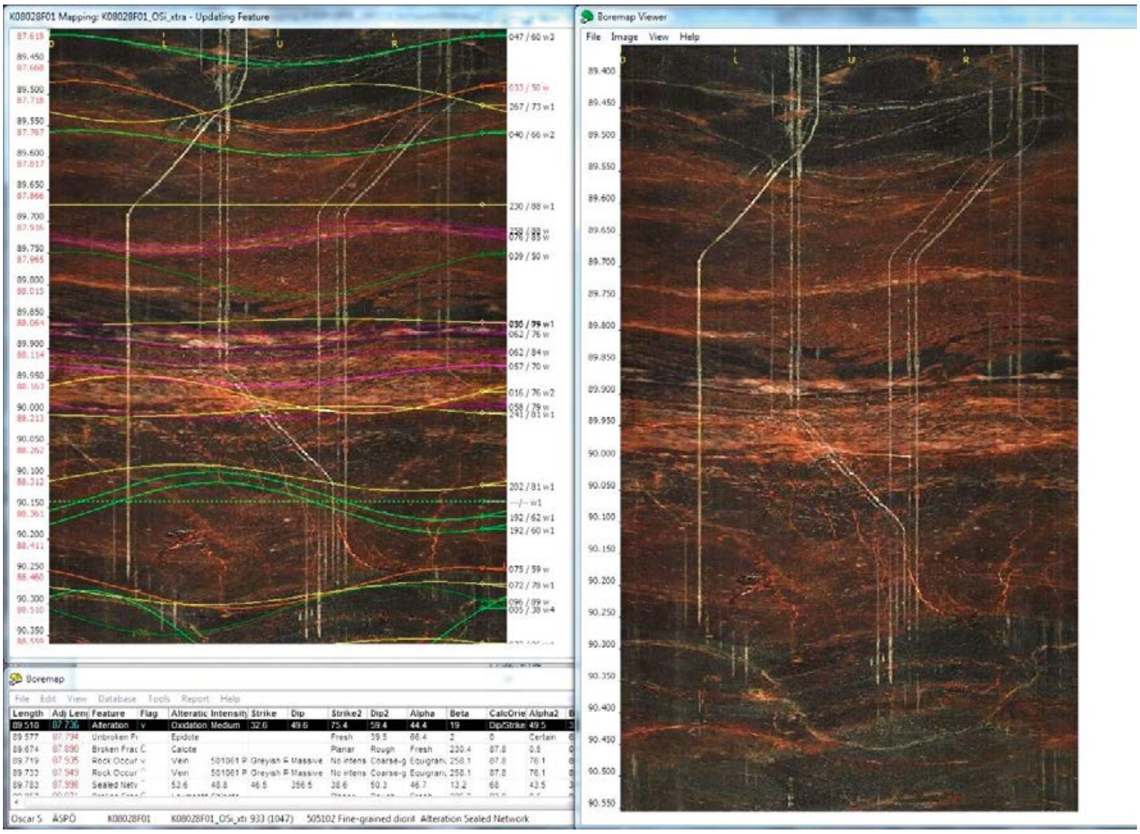


Figure 5-2. A good to acceptable quality OPTV-image from borehole K08028F01 as it is seen in the Boremap software. On the left side the borehole between 87.619–88.559 m adjusted length (red numbers) is shown. On the right hand side the same view without interpreted lines is shown from the Boremap viewer for comparison. The rock type is fine-grained diorite-gabbro, the alteration type is oxidation (red colouring) with the intensity set to medium. Two thin pegmatite-dykes are marked as well as several fractures both as yellow lines indicating broken fractures and green lines indicating unbroken fractures. The scratches seen on the borehole walls are probably from the drill rods and/or drill bit.

Table 5-3. Total number of fractures in borehole K08028F01. Total adjusted mapped length of borehole K08028F01 is calculated at 93.96 m, which is here divided into 94.39 − 2.28 = 92.11 m (core below casing) and 2.05 − 0.2 = 1.85 m (core within diameter fitting the casing). The lengths are then used for the calculations of fracture frequency (fractures/metre).

Borehole ID	Tot no of broken fractures	Fractures/metre	Tot no of unbroken fractures	Fractures/metre	Tot no of partly open fractures	Fractures/metre
K08028F01	292	3.108	263	2.799	14	0.149
K08028F01*	288	3.127	258	2.801	14	0.152
K08028F01**	4	2.162	5	2.703	0	0

*Length of core below casing (adjusted length: 92.11 m).

**Length of OPTV-core photo within casing diameter (adjusted length: 1.85 m).

The mean orientation (strike/dip) of the broken fractures in K08028F01 is 231/87, while the orientation of the unbroken fractures varies somewhat more, showing three dominant mean orientations, the first is 15/71, with a second sub-horizontal (approximately 0/0) and a third mean orientation of 121/88 (see Appendix A1.4).

Thirteen sealed networks were identified in the borehole with an average width of 0.6 m. Figure 5-3 illustrates an example of how sealed networks can appear in the OPTV-image in a fine-grained diorite-gabbro between approximately 84.7–86.5 m.

As can be seen from the WellCAD diagram in Appendix A1.1 the main concentration of sealed networks is between approximately 66.3–94.4 m, with an average width of approximately 2.1 m and an average strike/dip of 77/63. Four minor areas occur also with varying orientations (see Table 5-4 and Figure 5-4 as well as Appendices A1.1 and A1.4).

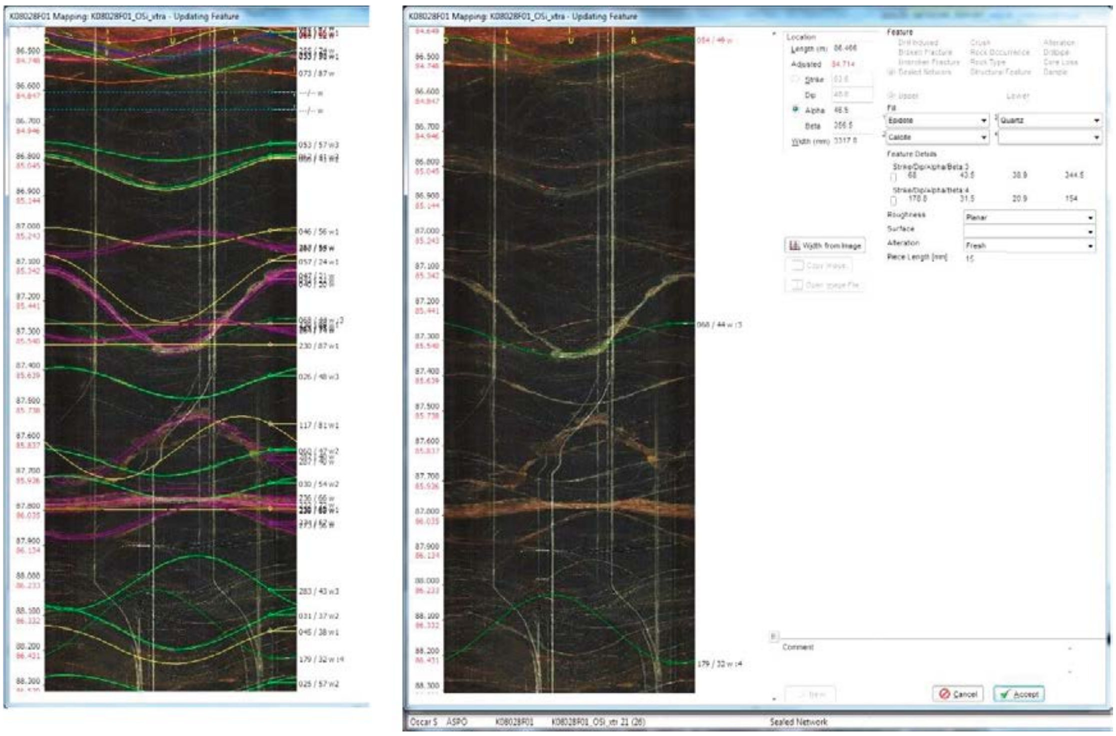


***Figure 5-3.** A good quality OPTV-image from borehole K08028F01 illustrating the borehole between 84.748–86.53 m adjusted length (red numbers). On the left all mapped features are shown (as lines of various colours) and on the right only the sealed network is shown for comparison (green lines, showing the top and the two main fracture directions), the lower most end of this sealed network is at 85.869 m and cannot be seen on these images. The rock type is fine-grained diorite-gabbro, which is the rock type where the epidote filled fractures of this sealed network can be most clearly seen.*

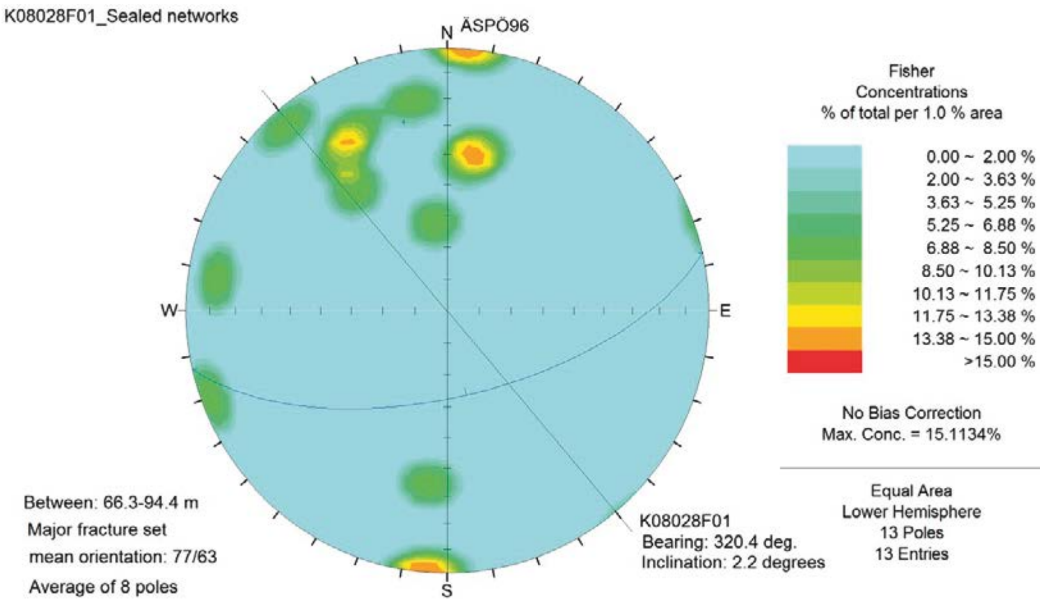


Figure 5-4. *Stereogram (strike/dip poles) showing data from fracture measurements in Boremap, in terms of upper contacts of sealed networks between 66.3–94.4 m in borehole K08028F01. The coordinate system is Äspö96. Bearing of borehole K08028F01 marked as a line. The diagrams have not been adjusted for borehole orientation bias.*

Table 5-4. Mapped Sealed Networks in borehole K08028F01. The table shows two groupings, one with two sealed networks occurring between 15.6–17.4 m and the other made up of eight sealed networks between 66.3–94.4 m. Average width is the difference between upper and lower contact of each individual sealed network in the borehole. Strike/dip is from upper contacts (set as a reference to give a sense of direction).

	Adjusted upper length (m)	Adjusted lower length (m)	Number of sealed networks	Average width (m)	Average orientation of upper contact: Strike/dip (degrees)
	13.4	13.7	1	0.3	98/78
Sealed networks	15.6	17.4	2	0.9	15/85
	37.3	39.5	1	2.3	9/78
	44.1	44.5	1	0.4	273/89
	66.3	94.4	8	2.1	77/63

One crush was mapped at approximately 37.6 m, which is within a greyish red, massive and coarse grained Pegmatite dyke (at 37.3–37.8 m). The crush has an orientation (upper contact) of 4/66 and is almost 3 cm wide, see Table 5-5 and Figure 5-5.

Table 5-5. Mapped crush in borehole K08028F01. Adjusted length from upper and lower coordinates of the intercept. Strike/dip is established from upper contact of crush zone (set as a reference to give a sense of direction).

Structure	Adjusted length (m)	Total width of zone (m)	Piece length (m)	Strike/dip (degrees)
Crush zone	37.56	0.027	0.005	4/66

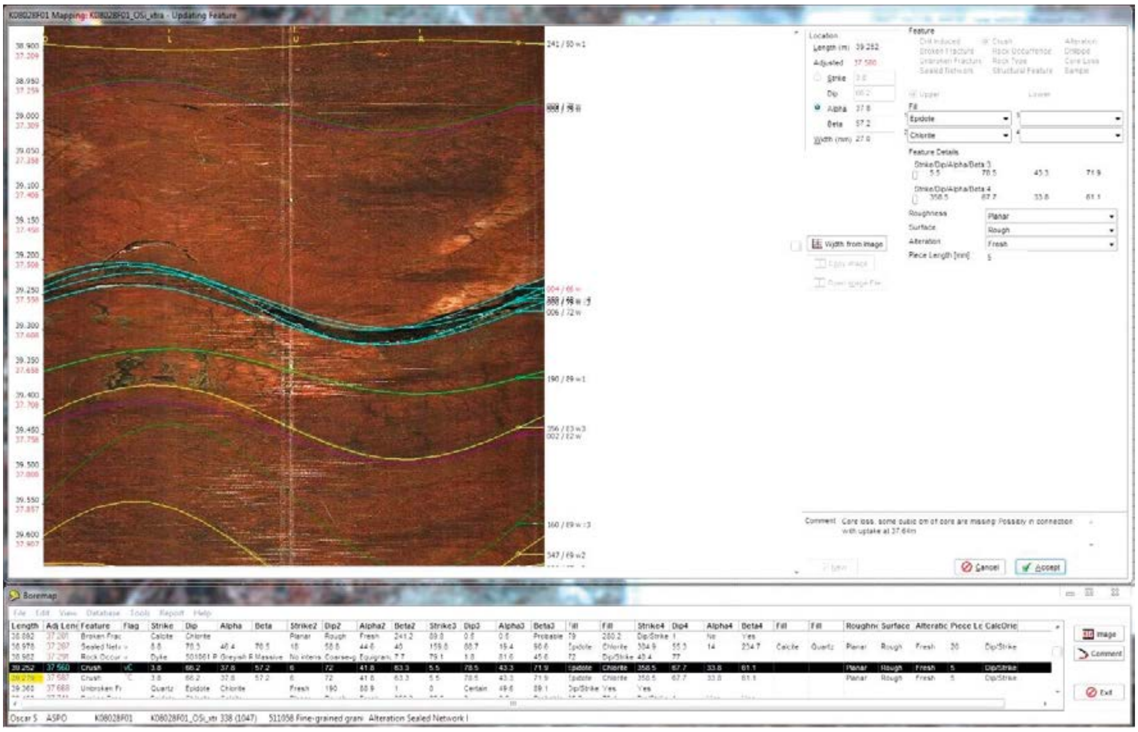


Figure 5-5. *An OPTV-image of good quality as it is seen in the Boremap software. Borehole K08028F01, 37.209–37.907 m adjusted length (red numbers), showing a coarse grained, massive, greyish red Pegmatite containing a thin crush zone (blue lines).*

5.4 Structures

The number of cataclastic structures in borehole K08028F01 is 15 with an average width of approximately 4 cm. The main concentration of cataclastic structures is between approximately 69.2–93.9 m with an average width of approximately 0.04 m and an average strike/dip of 26/73 (see Table 5-6 and Figure 5-6 as well as Appendices A1.1 and A1.4).

Table 5-6. Mapped cataclastic structures in borehole K08028F01. Twelve of the cataclastic structures which occur between 69.2–93.9 m are grouped together. Average width is the difference between upper and lower contact of the rock occurrences containing the cataclastic structure in each borehole. Strike/dip is an average from the approximate centre of each designated cataclastic structure.

Structure	Adjusted upper length (m)	Adjusted lower length (m)	Number of cataclastic structures	Average width (m)	Average orientation of structure: Strike/dip (degrees)
	22.486	22.513	1	0.027	90/46
	43.108	43.123	1	0.015	50/85
Cataclastic structure	49.980	50.022	1	0.042	245/39
	69.152	93.901	12	0.045	26/73

Other observed structures in the borehole are mylonite, ductile shear zone and breccia shown in Table 5-7, as well as banding and foliations of various intensities shown in Tables 5-8 and 5-9.

The mapped mylonitic structure is a relatively well defined band of strongly deformed rock within fine-grained granite (Figure 5-7 a). The main reason for categorizing it as a mylonite is the relatively sharp boundaries against the less deformed fine-grained granite, using the intensity weak to indicate that it could probably also be called a ductile shear zone.

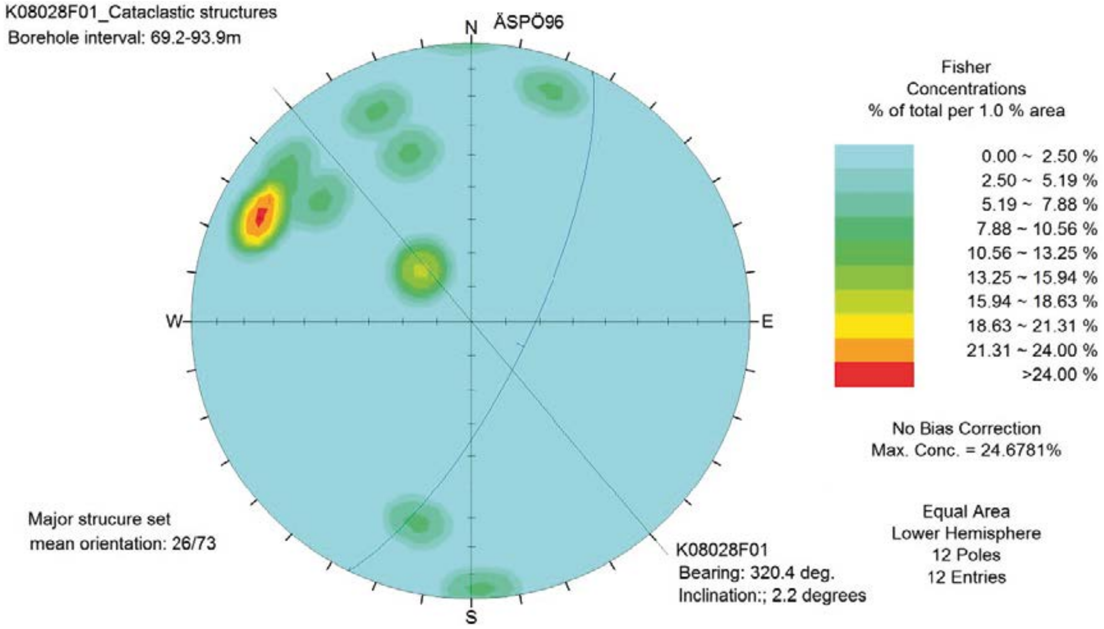


Figure 5-6. *Stereogram (strike/dip poles) showing data from structural measurements in Boremap. Upper contacts of cataclastic structures between 69.2–93.9 m in borehole K08028F01. The coordinate system is Äspö96. The bearing of borehole K08028F01 is marked as a line. The diagram is not adjusted for borehole orientation bias.*

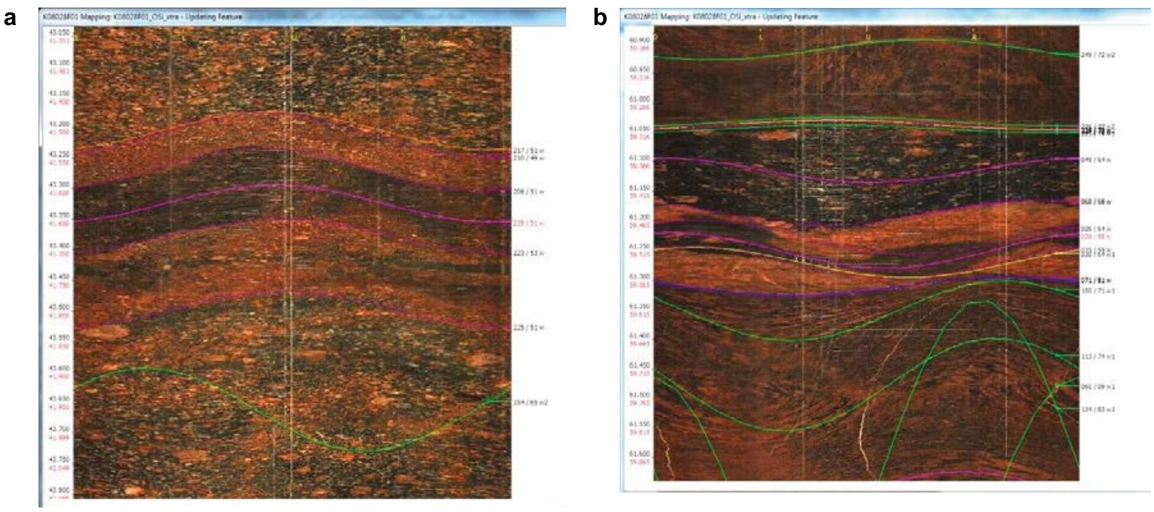


Figure 5-7. *OPTV-images of good quality from borehole K08028F01, screen dump from the Boremap software.* ***a)*** *41.351–42.099 m adjusted length (red numbers), showing a weak mylonitic structure (at 41.624 m) within an unspecified, weakly foliated, fine- to medium grained, greyish red fine-grained granite (between 41.6–41.7 m).* ***b)*** *59.166–59.865 m adjusted length (red numbers), showing a medium intensity ductile shear zone (at 59.515 m) within a medium to coarse grained, massive, greyish red Pegmatite vein (between 59.5–59.6 m).*

The marked upper and lower contacts of the ductile shear zone indicate only the most intense central deformation within a deformed pegmatite (Figure 5-7 b). The deformation zone as a whole is probably larger, with the diffuse upper border probably being at the foliated fine-grained granite at 57.623 m and possibly the lower border as far down as 63.453 m.

The breccia is an unspecified fine-grained diorite-gabbro, brecciated by a greyish fine-grained granite as well as medium grained Ävrö granodiorite, Figure 5-8.

Table 5-7. Mapped rock occurrences containing breccia, ductile shear zone and mylonite in borehole K08028F01. Upper and lower contacts are marked as Adj. sect. up (adjusted section up in m) and Adj. sect. low (adjusted section down in m) respectively. Width is the difference between the Adj. sect. up and Adj. sect. low. Strike/dip is established from the upper contact of the breccia, strike is given in the coordinate system Äspö96 and the lithology is as presented in Table 1-2.

Structure	Adj. sect. up	Adj. sect. low	Width (m)	Intensity	Strike	Dip	Lithology
Mylonite	41.568	41.677	0.109	Weak	219	51	Fine-grained granite
Ductile shear zone	59.492	59.534	0.042	Medium	39	55	Pegmatite
Breccia	66.286	67.008	0.722	Medium	253	28	Fine grained diorite-gabbro

Banding is only mapped in the first approximately 28 m of the borehole (see Table 5-8 and Figure 5-9), while foliation is mapped throughout the whole core accept between approximately 65–80 m, where the rock seems to be somewhat more massive (see Table 5-9 and Figure 5-9 a). The concentration of the foliation observed can thus be roughly divided into two groups, between approximately 0.5–65 m (with mean orientation 264/85) and approximately 80–94 m (with mean orientation 100/82 with a minor component 21/66), see Appendix A1.4. The mean orientation of the five measurements of banding is 262/79, while the mean orientation of all measured foliations is 266/83, see Appendix A1.4.

Table 5-8. Mapped banding in borehole K08028F01. Upper and lower contacts of rock occurrences containing the marked banded structure are marked as Adj. sect. up (adjusted section up in m) and Adj. sect. low (adjusted section down in m) respectively. Width is the difference between the Adj. sect. up and Adj. sect. low. The measured structural entity, attributed to a rock occurrence of a given width, is marked at a certain length (Length) along a line parallel to the core axis of the borehole within the rock occurrence. Strike is given in the coordinate system Äspö96 and the lithology is as given in Table 1-2.

Structure	Adj. sect.up	Adj. sect. low	Width (m)	Length (m)	Intensity	Strike	Dip	Lithology
Banded	1.701	2.200	0.499	1.875	Faint	265.9	85.9	Ävrö gr. dior.
	2.200		2.138	2.687	Faint	274.7	74.6	F. gr. granite
		4.338		3.898	Faint	110.3	67.1	
	12.536	12.644	0.108	12.566	Medium	262.4	79.5	F. gr. granite
	27.506	28.494	0.988	27.973	Medium	210.9	74.1	F. gr. granite

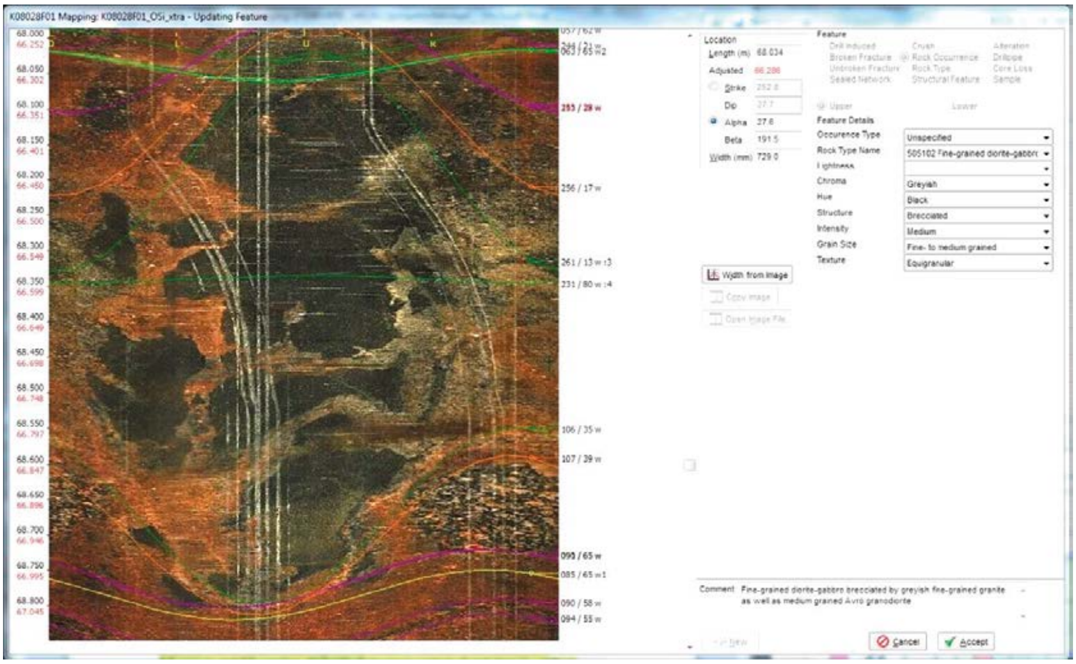


Figure 5-8. An OPTV-image of good quality from borehole K08028F01, screen dump from the Boremap software.An unspecified fine-grained diorite-gabbro brecciated by a greyish fine-grained granite and some medium grained Ävrö granodiorite occur between 66.252–67.045 m adjusted length (red numbers),

Table 5-9. Mapped foliation in borehole K08028F01. Upper and lower contacts of rock occurrences (and/or rock types) containing the marked foliation structure are marked as Adj. sect. up and Adj. sect. low respectively. Width is the difference between the Adj. sect. up and Adj. sect. low. The mapped structural entity, attributed to a rock occurrence of a given width, is marked at a certain length (Length) along a line parallel to the core axis of the borehole within the rock occurrence. Rows with no indicated length are rock occurrences where no structure has been marked in the Boremap mapping, the upper contact of the rock occurrence then becomes the designated strike/dip of the foliation.

Adj. sect. up	Adj. sect. low	Width (m)	Length (m)	Intensity	Strike	Dip	Lithology
0.231	1.701	1.470	0.501	Weak	241.6	62.6	Ävrö gr. dior.
5.000	5.478	0.478	5.391	Medium	236.5	69.3	F. gr. granite
4.832	5.647	0.815	5.564	Weak	218.3	77.5	F. gr. granite
6.204	6.257	0.053		Weak	272.4	65.5	F. gr. granite
8.429	8.767	0.338	8.636	Weak	94.5	64.0	F. gr. granite
10.376	10.487	0.111	10.417	Faint	99.1	83.1	F. gr. granite
12.468	12.516	0.048	12.502	Faint	259.8	84.4	F. gr. granite
12.536	12.644	0.108	12.596	Medium	262.2	83.1	F. gr. granite
12.617		1.500	12.910	Medium	268.7	79.2	F. gr. granite
	14.117		13.975	Medium	269.1	86.7	
14.117	14.594	0.477	14.243	Faint	89.7	80.3	Ävrö gr. dior.
18.482	18.609	0.127	18.546	Weak	258.7	70.5	F. gr. granite
23.436	23.529	0.093	23.478	Medium	49.1	64.3	F. gr. granite
24.821	26.034	1.213	25.842	Medium	255.0	88.4	F. gr. granite
26.029	26.092	0.063	26.058	Medium	72.9	86.0	F. gr. granite
27.506	28.494	0.988	28.408	Medium	241.5	69.9	F. gr. granite
31.456		5.101	31.495	Medium	92.1	89.2	F. gr. granite
			32.623	Weak	263.8	86.6	
	36.557		34.078	Medium	81.3	70.3	
35.625	36.038	0.413	35.924	Faint	78.6	66.7	Ävrö gr. dior.
38.793	38.872	0.079	38.836	Weak	240.4	41.3	F. gr. granite
39.604	39.874	0.270		Weak	172.8	25.3	F. gr. granite
41.568	41.677	0.109		Weak	207.8	50.6	F. gr. granite
45.505	45.635	0.130	45.584	Faint	254.9	78.5	F. gr. granite
46.839	47.629	0.790	47.597	Faint	237.4	48.0	F. gr. granite
48.488	48.556	0.068	48.526	Medium	272.5	49.0	F. gr. granite
50.253		1.386	50.702	Medium	101.9	84.3	F. gr. granite
	51.639		51.420	Medium	243.3	21.1	
53.770	54.372	0.602		Faint	246.8	81.8	F. gr. granite
54.835	54.966	0.131	54.919	Faint	71.1	80.3	F. gr. granite
57.623	59.303	1.680	57.955	Weak	278.5	68.8	F. gr. granite
59.303	59.451	0.148	59.379	Medium	48.5	63.5	Äspö diorite
59.576		3.425	59.925	Medium	274.1	81.1	F. gr. granite
	63.001		62.743	Medium	277.2	84.1	
63.273	63.641	0.368	63.453	Weak	288.8	74.7	F. gr. granite
63.641	64.028	0.387	63.831	Medium	284.5	77.3	Ävrö gr. dior.
64.298	65.652	1.354	64.432	Medium	88.2	48.1	F. gr. granite
64.689	64.771	0.082	64.759	Medium	93.6	55.7	Ävrö gr. dior.
63.001	67.157	4.156	64.921	Medium	87.7	52.8	Ävrö gr. dior.
64.996	65.170	0.174	65.077	Medium	82.5	44.0	Ävrö gr. dior.
65.881	66.004	0.123		Weak	84.5	44.6	F. gr. granite
79.850		4.870	80.074	Weak	98.3	80.6	Ävrö gr. dior.
	84.720		80.617	Weak	268.5	82.1	
80.271	80.334	0.063	80.304	Medium	102.8	85.8	F. gr. granite
80.710	80.919	0.209	80.835	Weak	70.8	74.1	F. gr. granite
85.987	86.025	0.038	86.008	Weak	231.6	72.4	F. gr. granite
88.126	88.214	0.088	88.157	Weak	56.9	70.1	Pegmatite
90.205	93.880	3.675	90.802	Medium	39.1	59.4	Ävrö gr. dior.
92.437	92.479	0.042	92.455	Weak	8.0	74.3	Pegmatite
92.540	92.692	0.152	92.618	Weak	16.6	63.3	Pegmatite
93.750	93.878	0.128		Weak	26.8	73.3	F. gr. granite
93.880	94.390	0.510	93.926	Medium	25.9	70.6	Ävrö gr. dior.

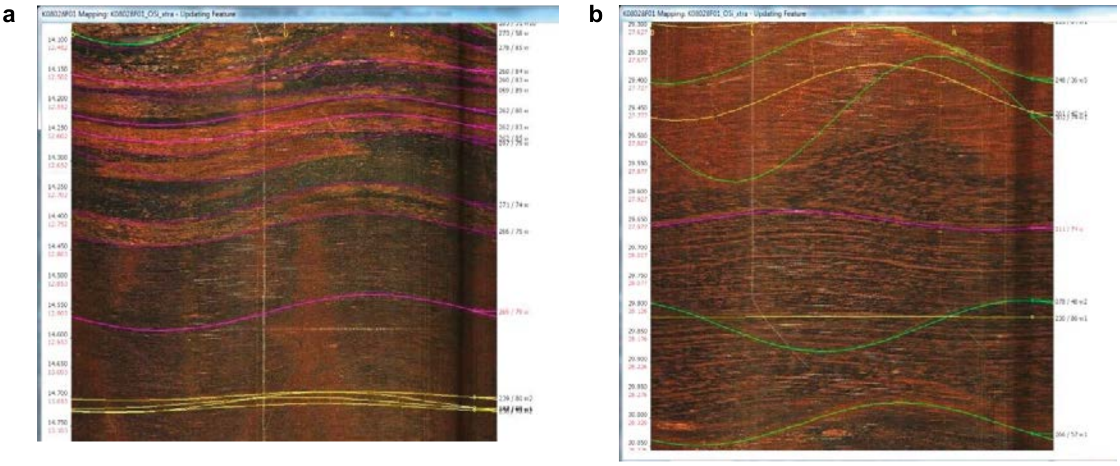


Figure 5-9. *OPTV-images of good quality from borehole K08028F01, screen dump from the Boremap software. a) 12.452–13.103 m adjusted length (red numbers), showing both faint foliation at approximately 12.5 m and medium intensity banding at approximately 12.6 m. b) 27.627–28.376 m adjusted length (red numbers), showing medium intensity banding at approximately 28 m.*

References

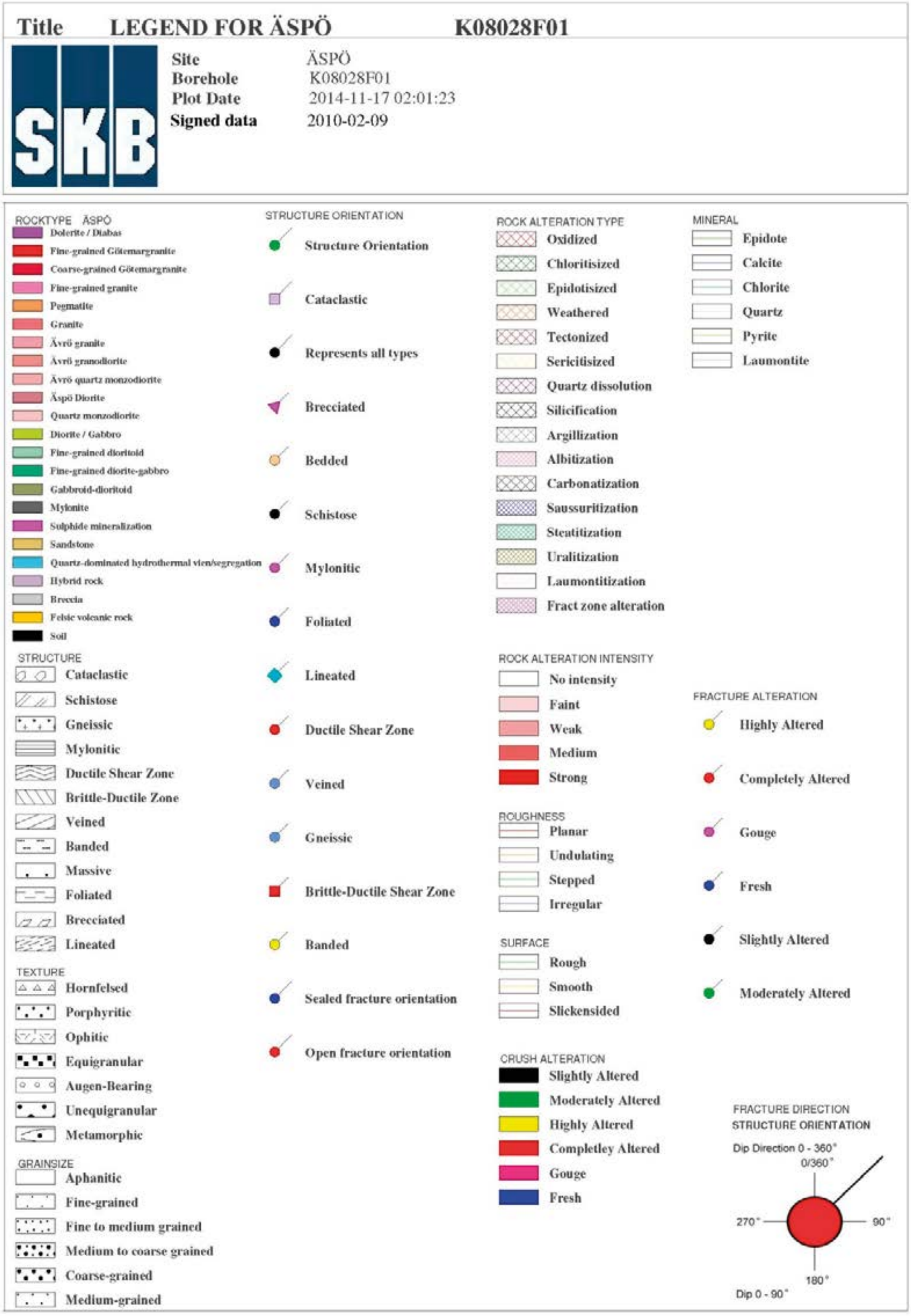
SKB's (Svensk Kärnbränslehantering AB) publications can be found at www.skb.com/publications.

Ehrenborg J, Dahlin P, 2005. Oskarshamn site investigation. Boremap mapping of core drilled boreholes KLX05. SKB P-05-224, Svensk Kärnbränslehantering AB.

ISRM, 1978. Suggested methods for the quantitative description of discontinuities in rock masses. International Journal of Rock Mechanics and Mining Science 15, 319–368.

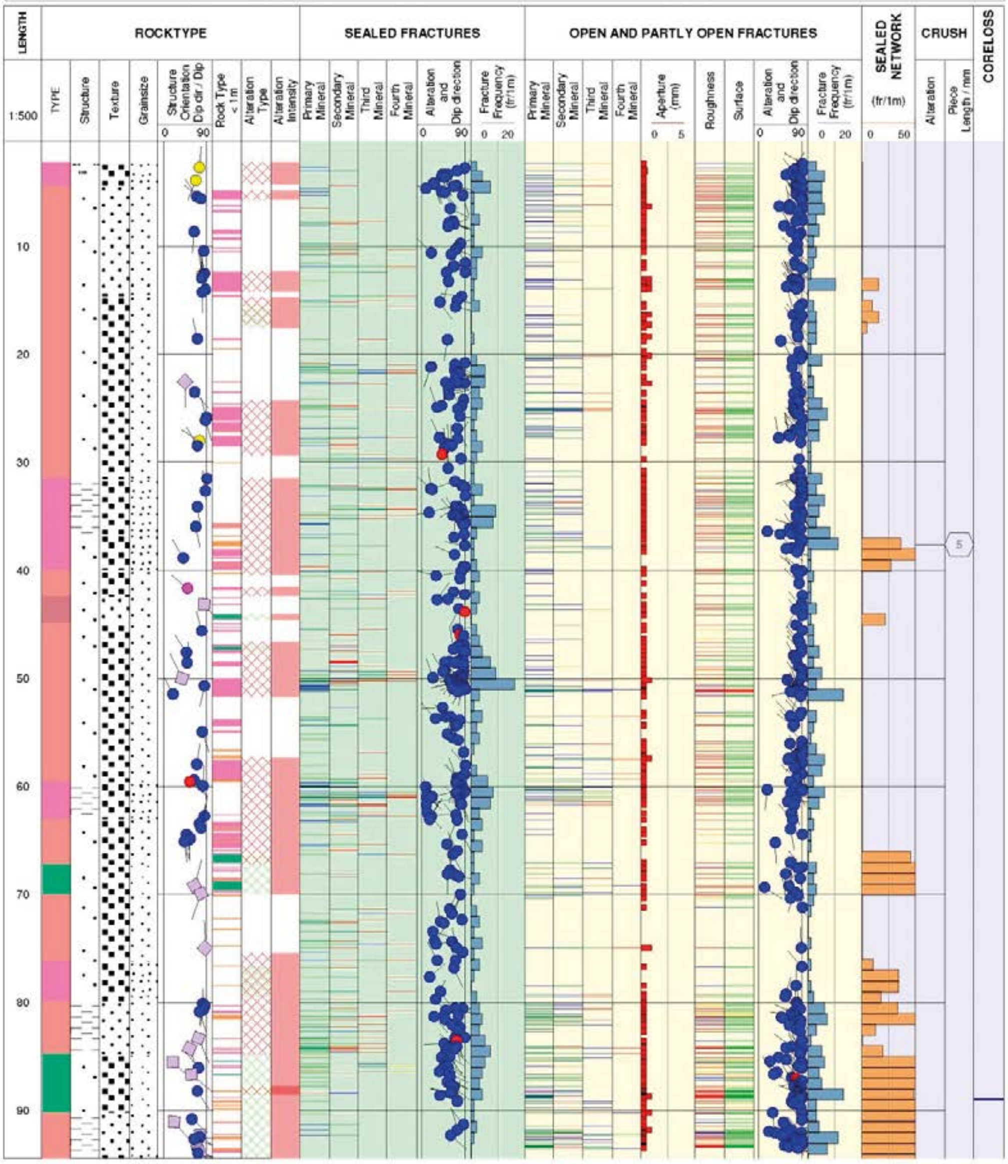
Appendix 1

A1.1 WellCAD presentation of the mapping results for K08028F01



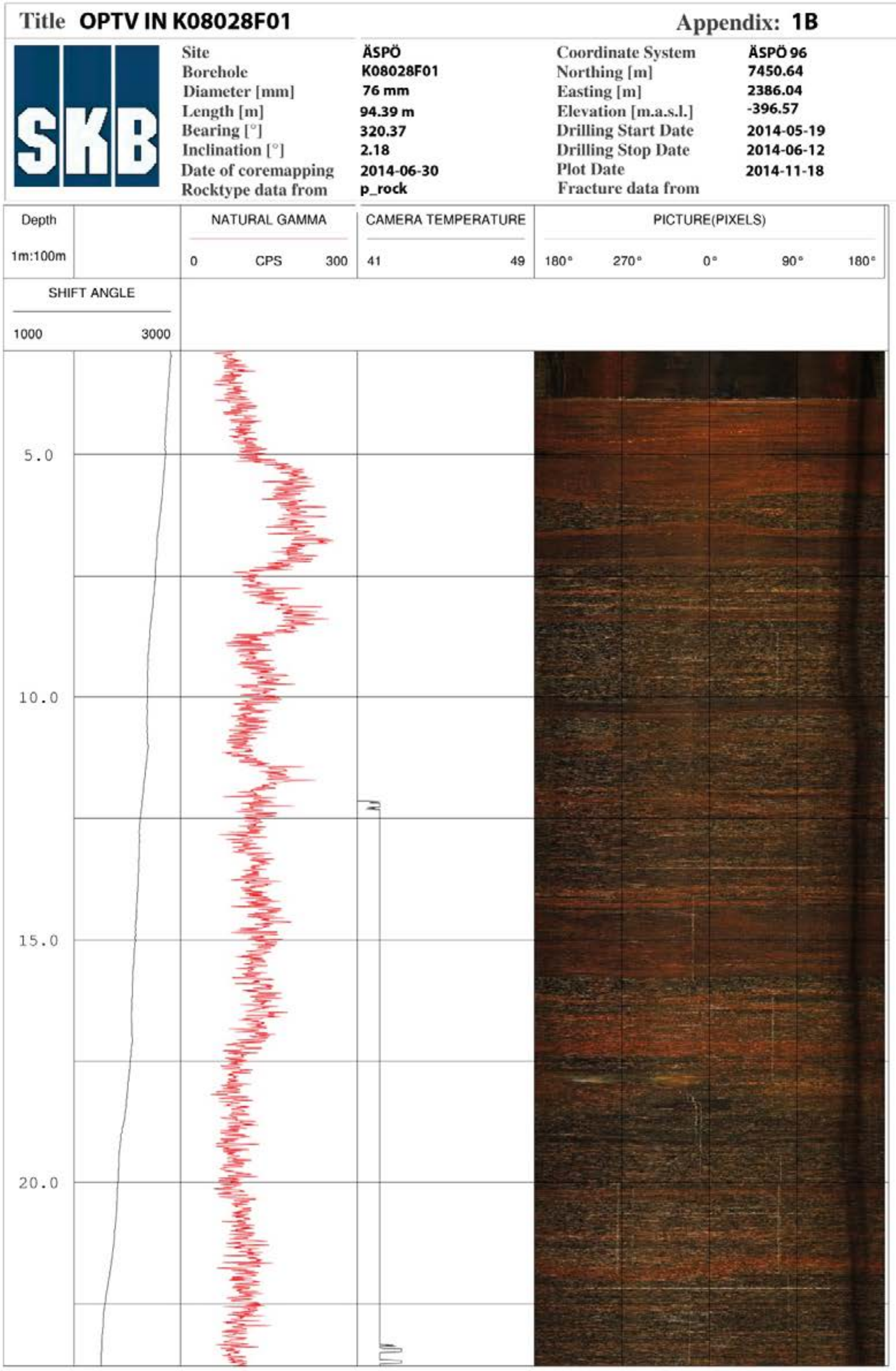
Title GEOLOGY IN K08028F01 **Appendix: 1A**

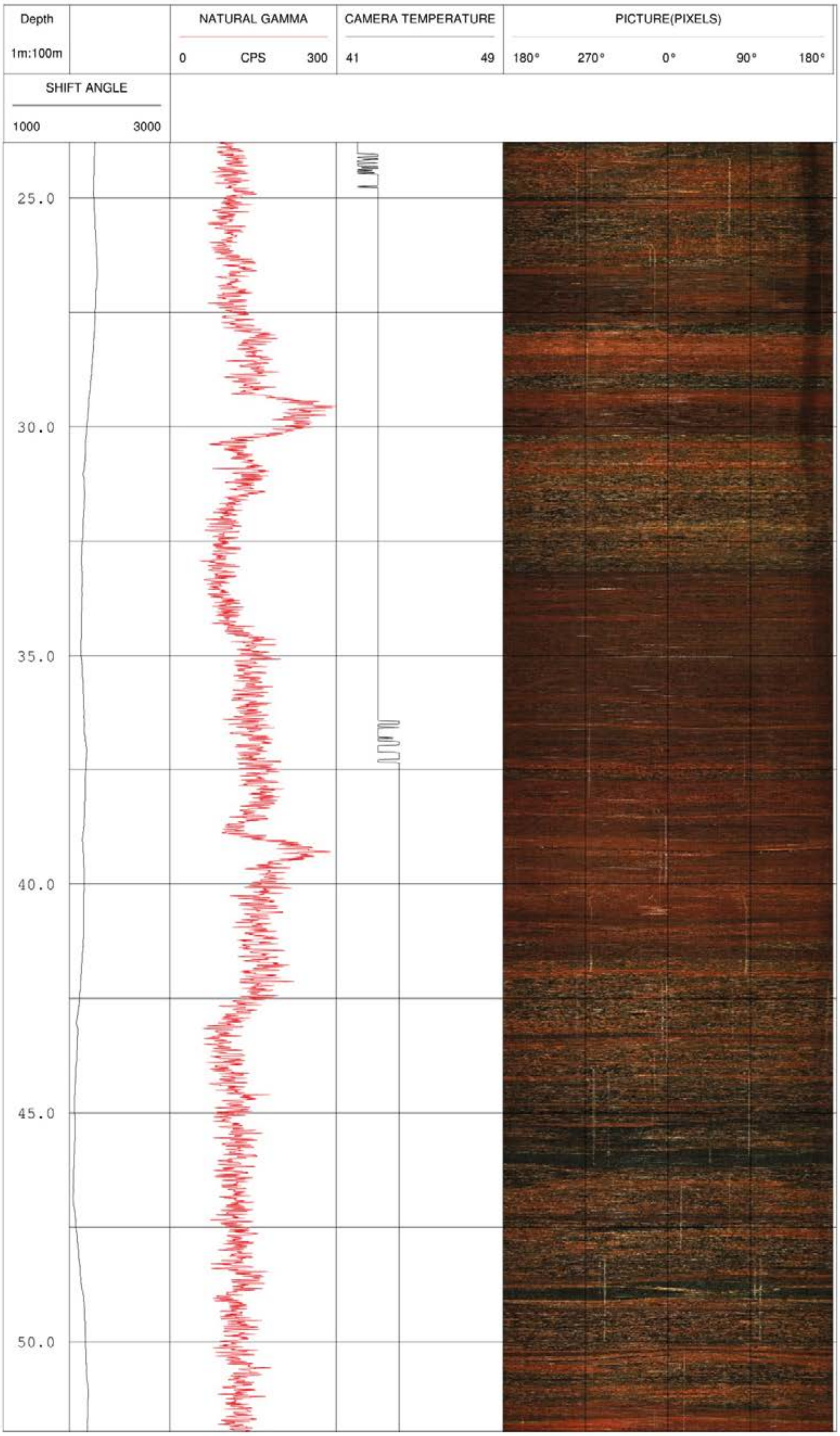
Site	ÄSPÖ	**Coordinate System**	ÄSPÖ96
Borehole	K08028F01	**Northing [m]**	7450.64
Diameter [mm]	76	**Easting [m]**	2386.04
Length [m]	94.390	**Elevation [m.a.s.l.]**	-396.57
Bearing [°]	320.37	**Drilling Start Date**	2014-05-19 14:20:00
Inclination [°]	2.18	**Drilling Stop Date**	2014-06-12 11:32:00
Date of coremapping	2014-06-30 11:02:00	**Plot Date**	2014-11-17 02:01:23
Rocktype data from	p_rock	**Signed data**	

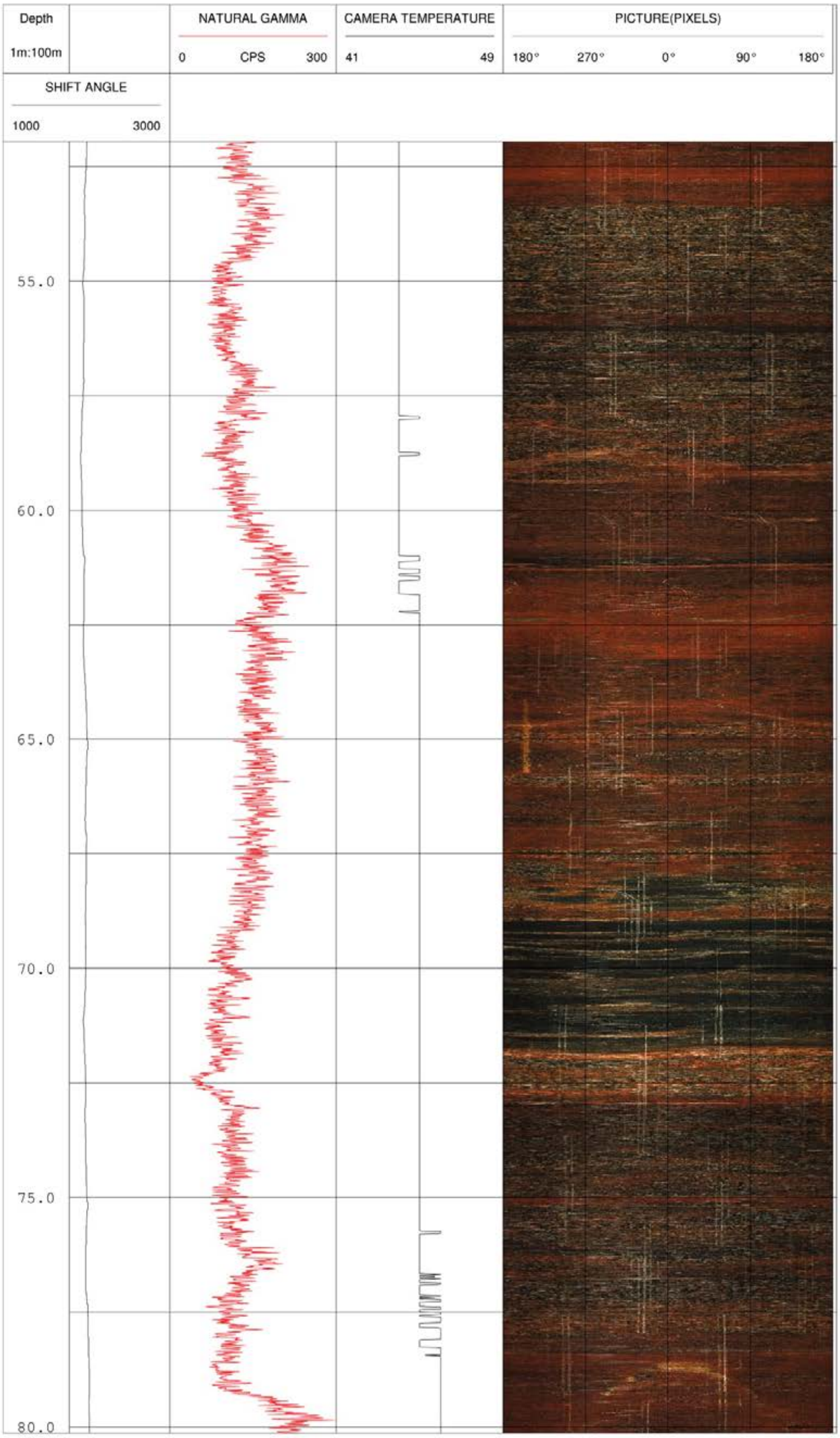


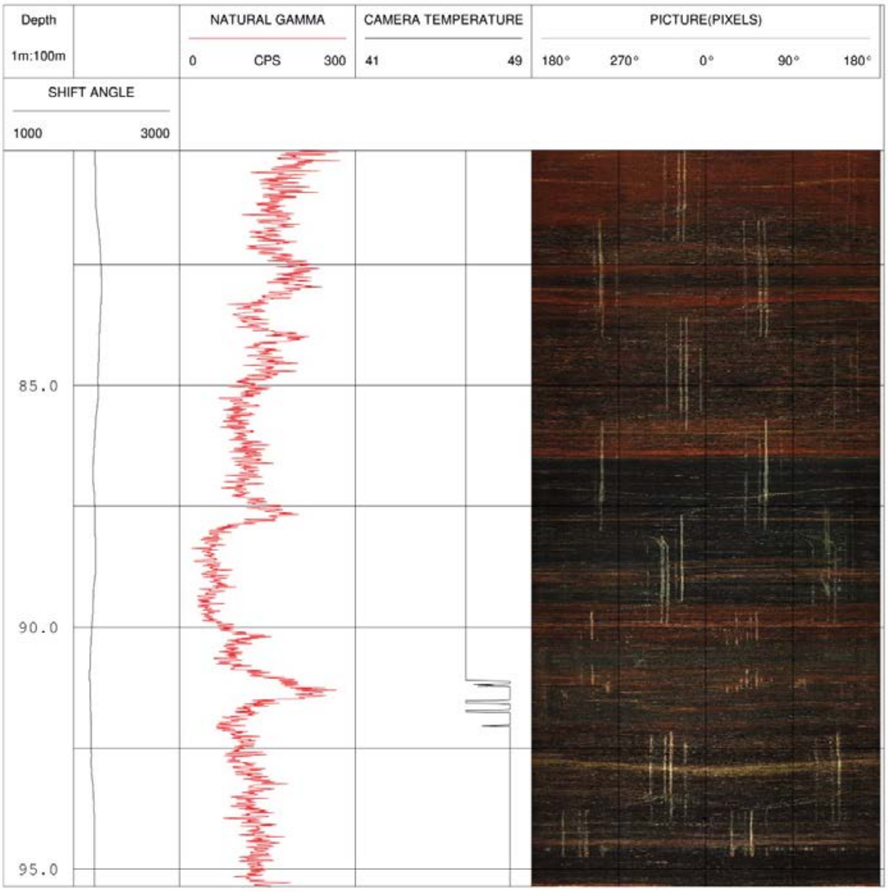
A1.2 OPTV image of borehole K08028F01

The orientation of the borehole figure is given in degrees: 0° = up, 180° = down, 270° = left and 90° = right.




Depth
1m:100m
NATURAL GAMMA
0
CPS
300
CAMERA TEMPERATURE
41
49
PICTURE(PIXELS)
180°
270°
0°
90°
180°
SHIFT ANGLE
1000
3000
25.0
30.0
35.0
40.0
45.0
50.0


Depth
1m:100m
NATURAL GAMMA
0 CPS 300
CAMERA TEMPERATURE
41 49
PICTURE(PIXELS)
180° 270° 0° 90° 180°
SHIFT ANGLE
1000 3000
55.0
60.0
65.0
70.0
75.0
80.0



A1.3 BIPS image of borehole K08028F01

Project name: ÄSPÖ HRL

Image file	**: d:\work\sphrl~1\aptd3h~1\bips\k08028~1.bip**
BDT file	**:**
Locality	**: ASPO**
Bore hole number	**: K08028F1**
Date	**: 14/06/24**
Time	**: 09:51:00**
Depth range	**: 2.000 - 93.431 m**
Azimuth	**: 0**
Inclination	**: -90**
Diameter	**: 76.0 mm**
Magnetic declination	**: 0.0**
Span	**: 4**
Scan interval	**: 0.25**
Scan direction	**: To bottom**
Scale	**: 1/25**
Aspect ratio	**: 180 %**
Pages	**: 7**
Color	**: +0 +0 +0**

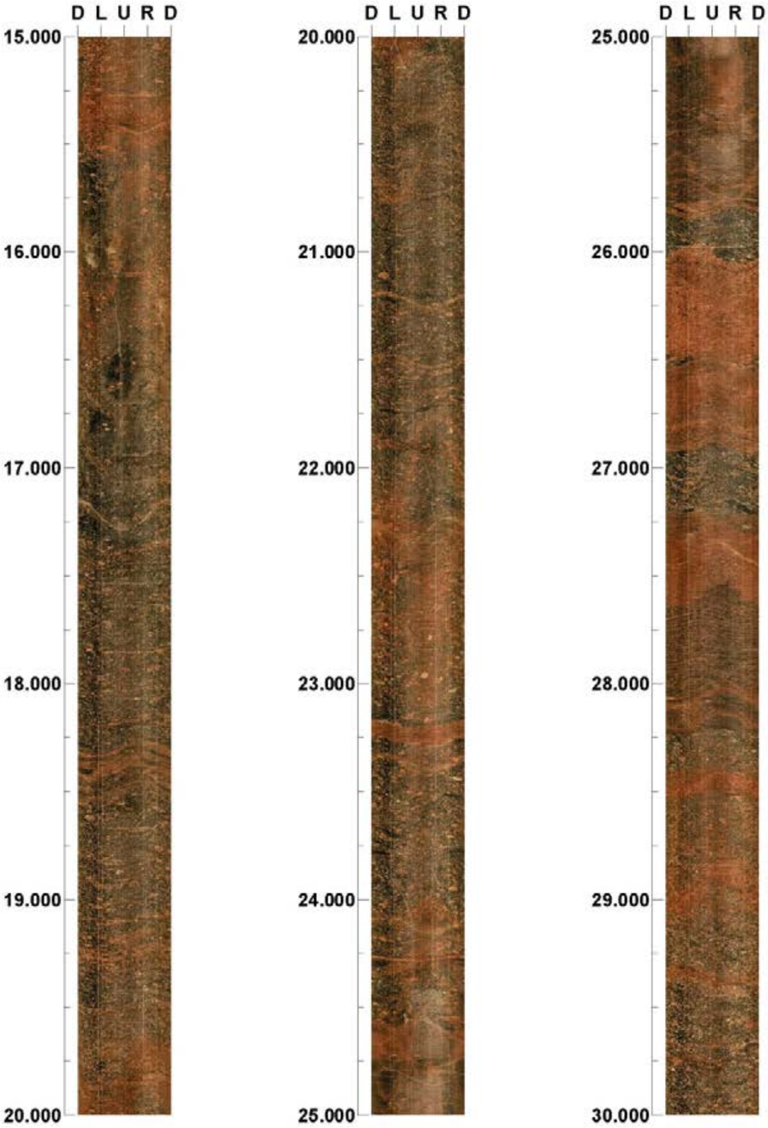
Project name: ÄSPÖ HRL
Bore hole No.: K08028F1 Azimuth: 0 Inclination: -90

Depth range: 0.000 - 15.000 m

(1 / 7) Scale: 1/25 Aspect ratio: 180 %

Project name: ÄSPÖ HRL
Bore hole No.: K08028F1 **Azimuth: 0** **Inclination: -90**

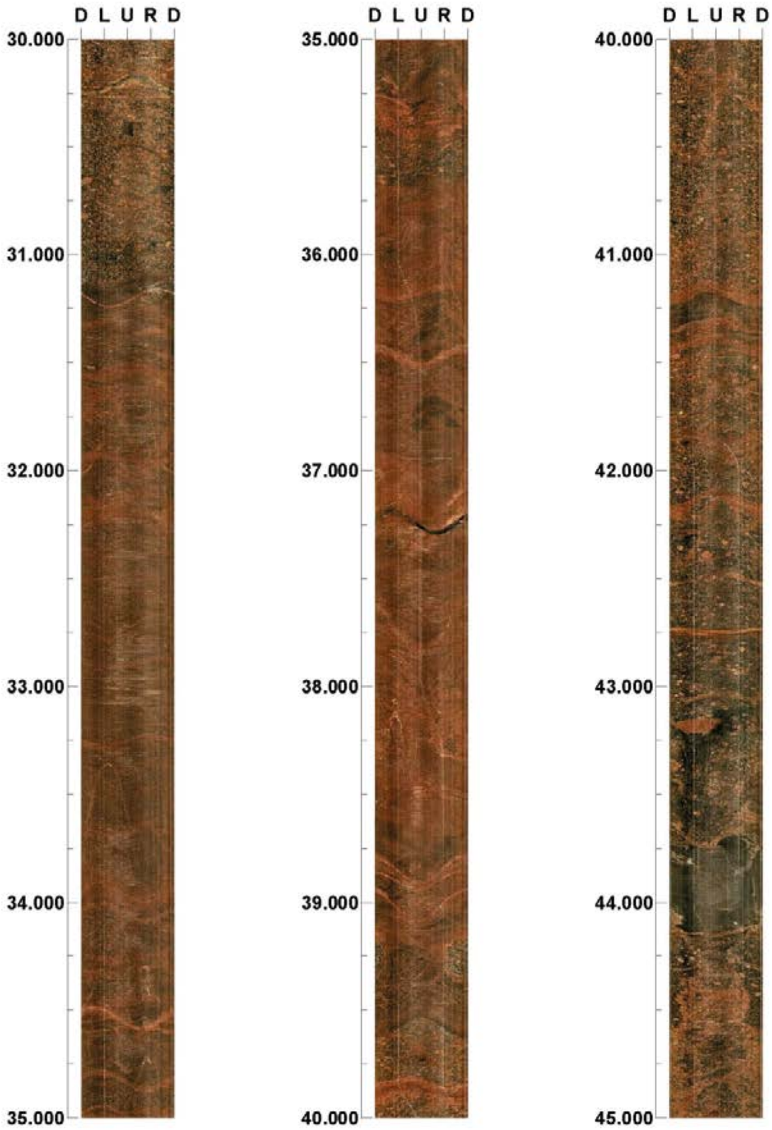
Depth range: 15.000 - 30.000 m



(2 / 7) **Scale: 1/25** **Aspect ratio: 180 %**

Project name: ÄSPÖ HRL
Bore hole No.: K08028F1 **Azimuth: 0** **Inclination: -90**

Depth range: 30.000 - 45.000 m



(3 / 7) **Scale: 1/25** **Aspect ratio: 180 %**

Project name: ÄSPÖ HRL
Bore hole No.: K08028F1 **Azimuth: 0** **Inclination: -90**

Depth range: 45.000 - 60.000 m

(4 / 7) **Scale: 1/25** **Aspect ratio: 180 %**

Project name: ÄSPÖ HRL
Bore hole No.: K08028F1 **Azimuth: 0** **Inclination: -90**

Depth range: 60.000 - 75.000 m

(5 / 7) **Scale: 1/25** **Aspect ratio: 180 %**

Project name: ÄSPÖ HRL
Bore hole No.: K08028F1 **Azimuth: 0** **Inclination: -90**

Depth range: 60.000 - 75.000 m

(5 / 7) **Scale: 1/25** **Aspect ratio: 180 %**

Project name: ÄSPÖ HRL
Bore hole No.: K08028F1 **Azimuth: 0** **Inclination: -90**

Depth range: 90.000 - 93.431 m

(7 / 7) **Scale: 1/25** **Aspect ratio: 180 %**

A1.4 Stereonets of all logged fractures, all broken fractures, all unbroken fractures, all partly open fractures, sealed networks, cataclastic structures, banding and foliations in borehole K08028F01

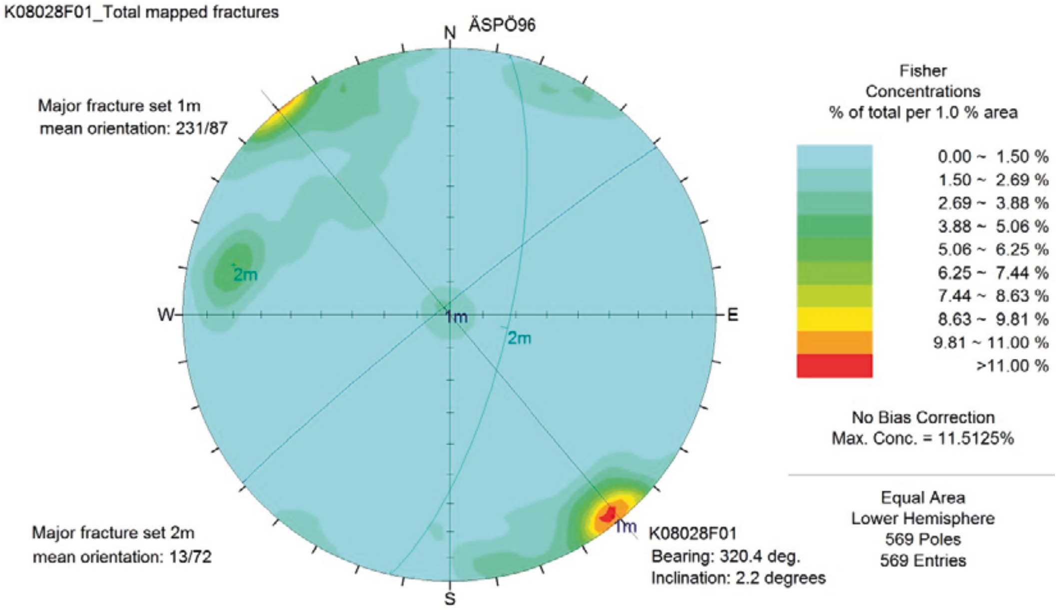


Figure A1-1. *Data from Boremap mapping of all logged fractures in borehole K08028F01. The coordinate system is Äspö96. Bearing of borehole K08028F01 marked as a line. Stereogram (strike/dip poles). Fourteen fractures do not cut the core and therefore have the designated strike/dip 0/0. The diagrams have not been adjusted for borehole orientation bias.*

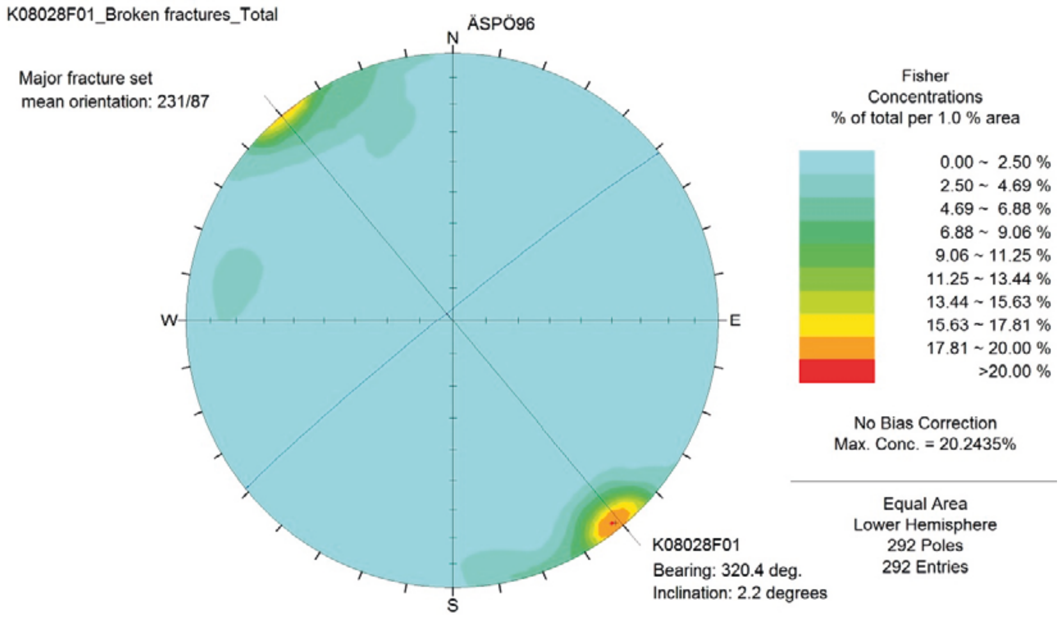


Figure A1-2. *Data from Boremap mapping of all broken fractures in borehole K08028F01. The coordinate system is Äspö96. Bearing of borehole K08028F01 marked as a line. Stereogram (strike/dip poles). One fracture does not cut the core and therefore has the designated strike/dip 0/0. The diagrams have not been adjusted for borehole orientation bias.*

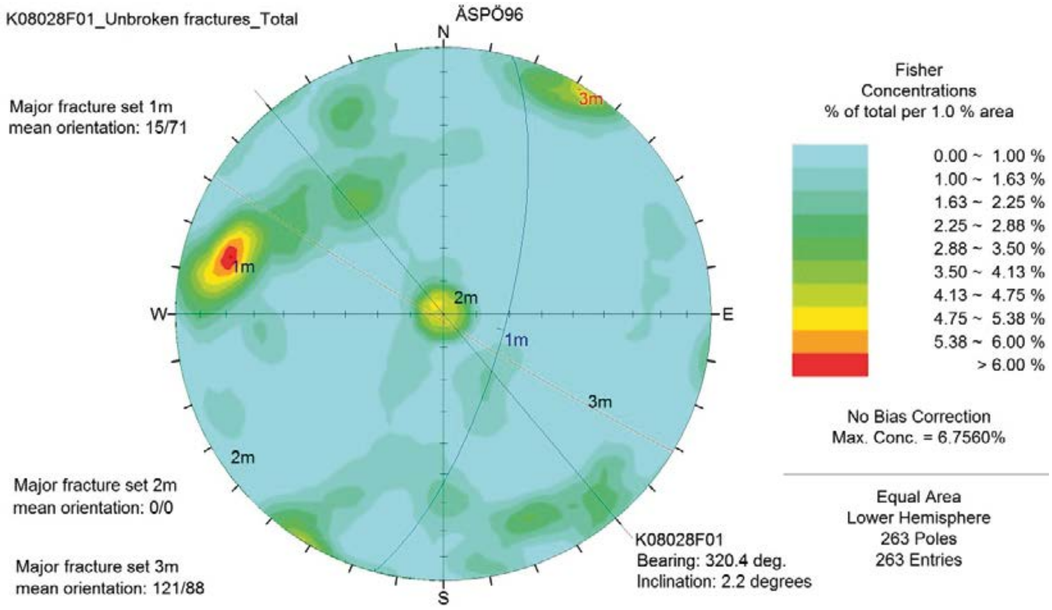


Figure A1-3. *Data from Boremap mapping of all unbroken fractures in borehole K08028F01. The coordinate system is Äspö96. Bearing of borehole K08028F01 marked as a line. Stereogram (strike/dip poles). Eleven fractures do not cut the core and therefore have the designated strike/dip 0/0. The diagrams have not been adjusted for borehole orientation bias.*

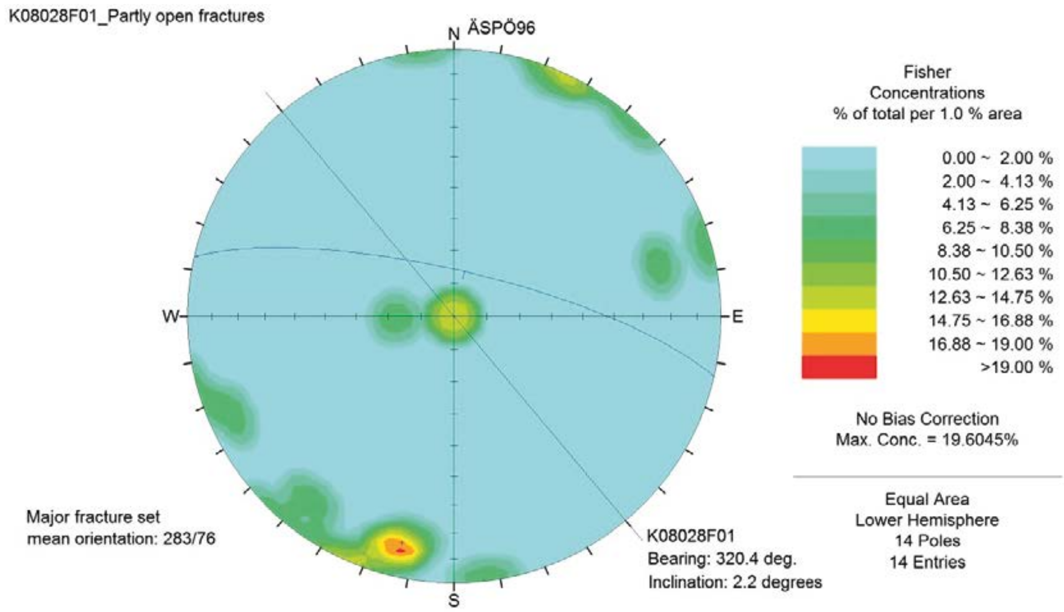


Figure A1-4. *Data from Boremap mapping of all partly open fractures in borehole K08028F01. The coordinate system is Äspö96. Bearing of borehole K08028F01 marked as a line. Stereogram (strike/dip poles). Two fractures do not cut the core and therefore have the designated strike/dip 0/0. The diagrams have not been adjusted for borehole orientation bias.*

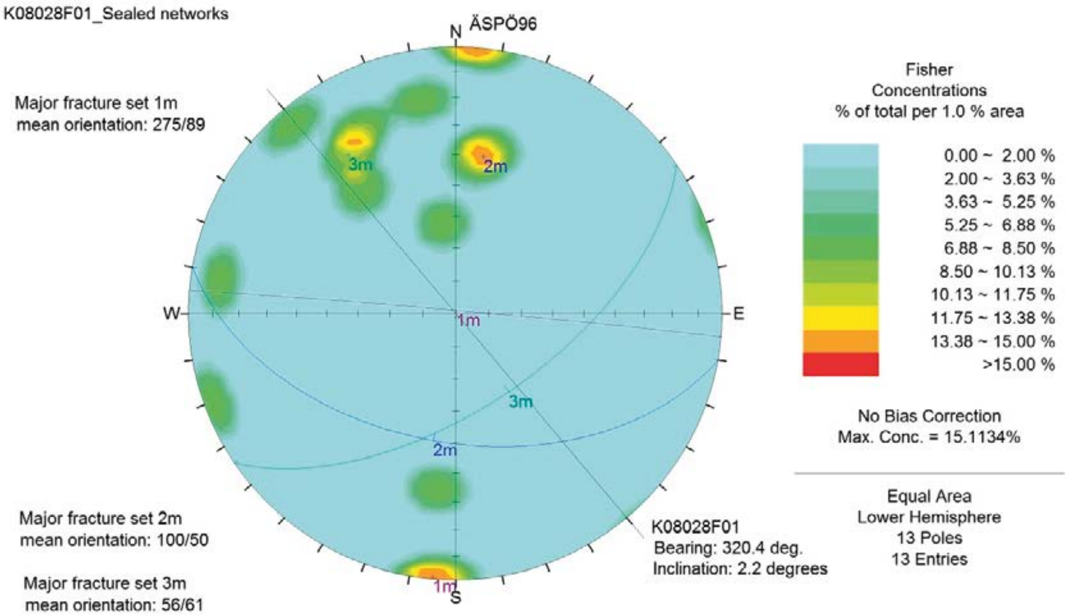


Figure A1-5. *Data from measurements in Boremap showing upper contacts of sealed networks in borehole K08028F01. The coordinate system is Äspö96. Bearing of borehole K08028F01 marked as a line. Stereogram (strike/dip poles). The diagrams have not been adjusted for borehole orientation bias.*

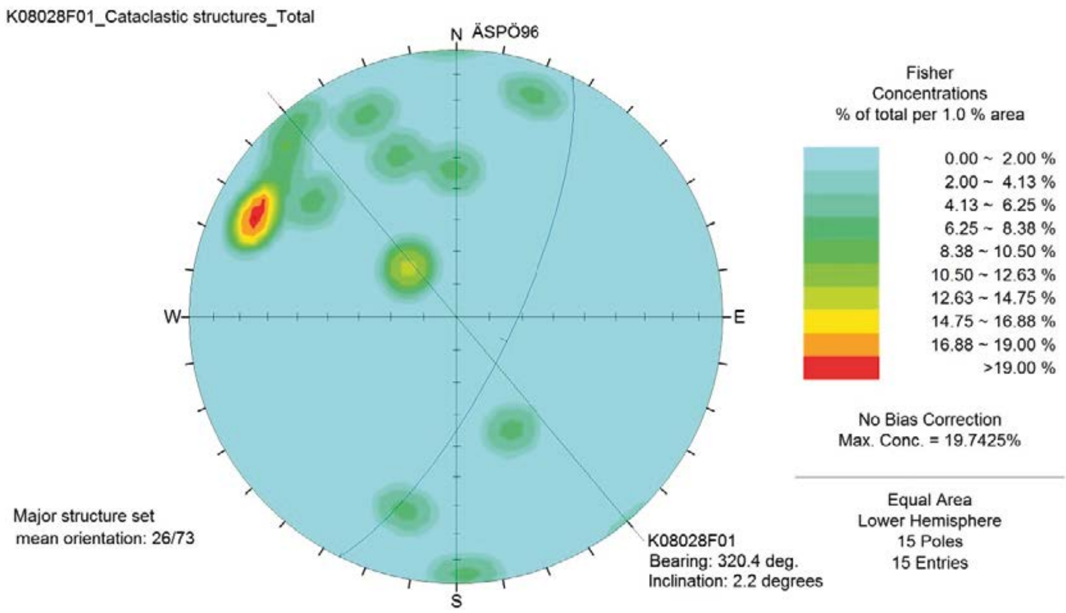


Figure A1-6. *Data from structural measurements in Boremap showing cataclastic structures in borehole K08028F01. The coordinate system is Äspö96. Bearing of borehole K08028F01 marked as a line. Stereogram (strike/dip poles). The diagrams have not been adjusted for borehole orientation bias.*

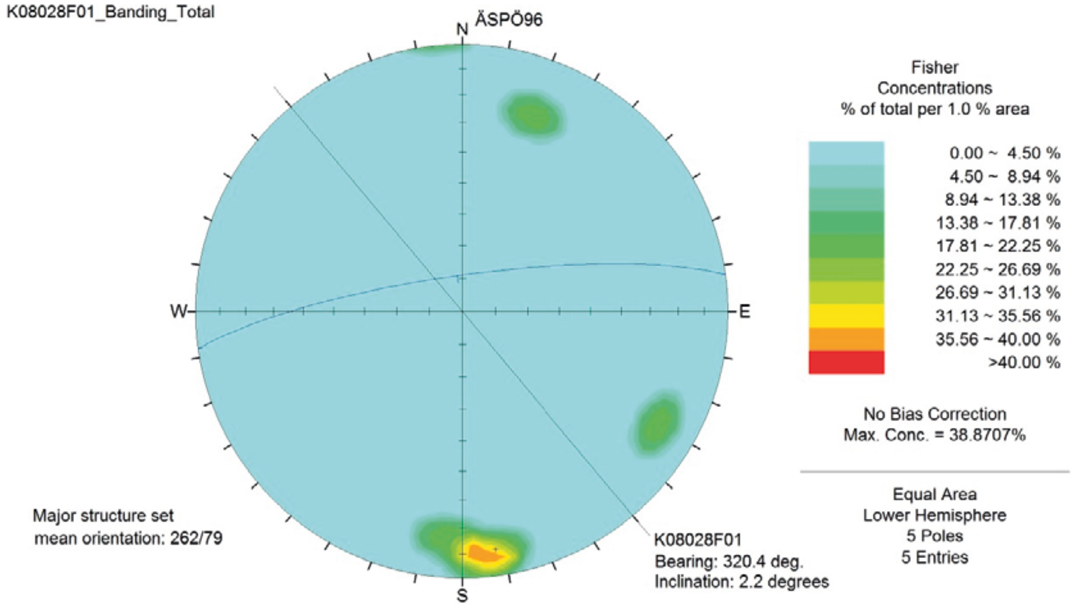


Figure A1-7. *Data from structural measurements in Boremap of banding in borehole K08028F01. The coordinate system is Äspö96. Bearing of borehole K08028F01 marked as a line. Stereogram (strike/dip poles). The diagrams have not been adjusted for borehole orientation bias.*

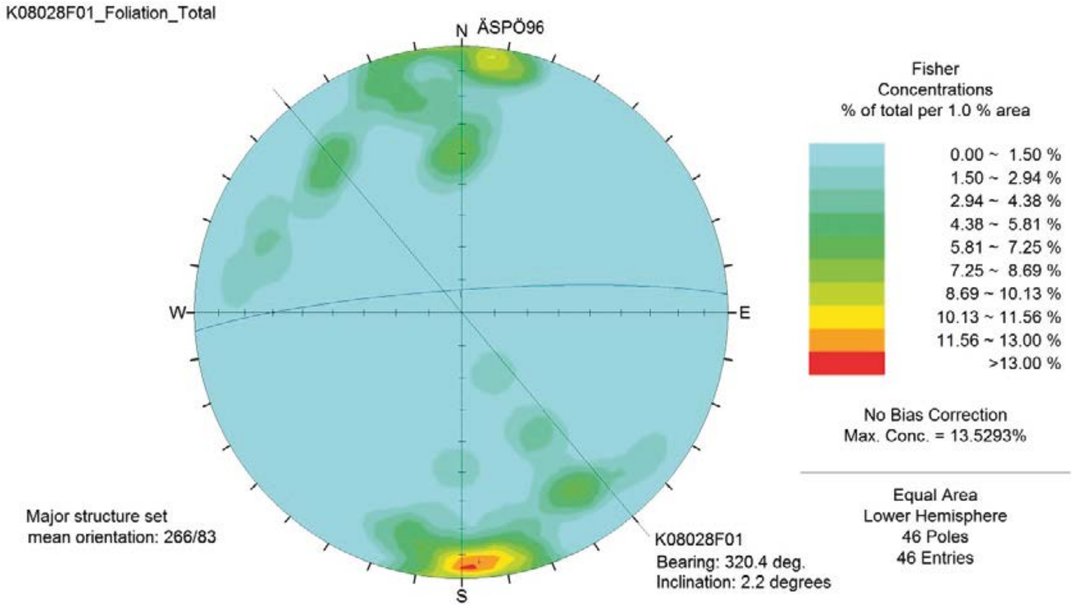


Figure A1-8. *Data from structural measurements in Boremap of foliations in borehole K08028F01. The coordinate system is Äspö96. Bearing of borehole K08028F01 marked as a line. Stereogram (strike/dip poles). The diagrams have not been adjusted for borehole orientation bias.*

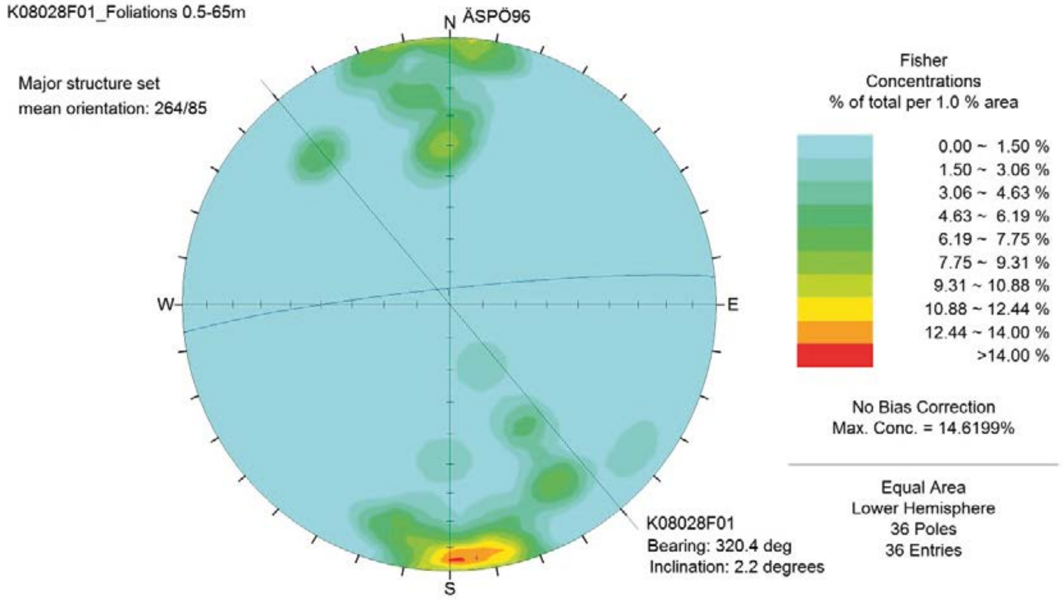


Figure A1-9. *Data from structural measurements in Boremap of foliations in borehole K08028F01 between 0.5–65 m. The coordinate system is Äspö96. Bearing of borehole K08028F01 marked as a line. Stereogram (strike/dip poles). The diagrams have not been adjusted for borehole orientation bias.*

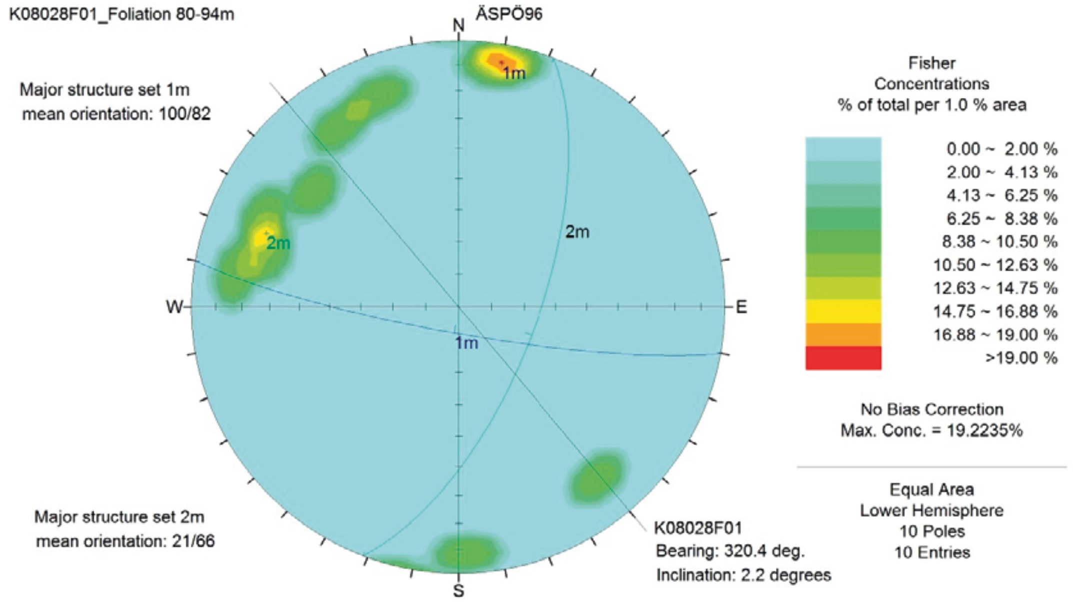


Figure A1-10. *Data from structural measurements in Boremap of foliations in borehole K08028F01 between 80–94 m. The coordinate system is Äspö96. Bearing of borehole K08028F01 marked as a line. Stereogram (strike/dip poles). The diagrams have not been adjusted for borehole orientation bias.*

Arkitektkopia AB, Bromma, 2017

SKB is responsible for managing spent nuclear fuel and radioactive waste produced by the Swedish nuclear power plants such that man and the environment are protected in the near and distant future.

skb.se