P-07-71

Oskarshamn site investigation

Simplified Boremap mapping of percussion drilled telescope boreholes KLX08, KLX09, KLX10, KLX11A, KLX19A and KLX21B

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March 2007

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Abstract

Eighteen deep cored boreholes with the upper ca 100 m percussion drilled (telescope holes) were drilled in the Laxemar subarea, eleven had the percussion drilled part BIPS logged resulting in six images of adequate quality for simplified Boremap mapping; KLX08, KLX09, KLX10, KLX11A, KLX19A and KLX21B. Boreholes KLX08, KLX09, KLX10 and KLX21B are located in the central and north-eastern part, while KLX11A and KLX19A are situated in the south-western part of the Laxemar subarea.

The purpose of the activity reported here is to map the lithology and structural parameters in the percussion boreholes based on results from drilling in conjunction with digital BIPS-images (Borehole Image Processing System) of the borehole walls.

The dominating rock type of the mapped boreholes KLX08, KLX09, KLX10 and KLX21B is Ävrö granite, while boreholes KLX11A and KLX19A are dominated by quartz monzodiorite. Small amounts of fine-grained diorite-gabbro occur in KLX08, KLX09, KLX19A and KLX21B. A few pegmatite dykes and veins cut the rock in KLX19A, while the rocks in all boreholes are cut by minor amounts of fine-grained granite dykes and veins.

Water yielding crush zone occurs only in the percussion drilled part of borehole KLX19A.

Alteration occurs in the form of red staining (oxidation), mainly of weak intensity, except in KLX21B where medium intensity alteration occurs.

The present report comprises a description of the applied equipment and the performed activities, the observations, data delivery together with a presentation and discussion of the results.

Sammanfattning

Arton djupa kärnborrhål borrade i Laxemar området har de översta ca 100 m hammarborrade (teleskopiska hål), den hammarborrade delen BIPS loggades i elva av dessa, som resulterade i sex bilder av sådan kvalitet att en förenklad Boremap kartering kunde utföras; KLX08, KLX09, KLX10, KLX11A, KLX19A och KLX21B. Borrhålen KLX08, KLX09, KLX10 och KLX21B är placerade i centrala och nordöstliga delen, medan KLX11A och KLX19A finns i sydvästra delen av delområde Laxemar vid platsundersökningen Oskarshamn.

Syftet med aktiviteten som rapporteras här är att kartera litologiska och strukturella parametrar i hammarborrhålen baserad på resultaten från borrningen i förbindelse med digitala BIPS-bilder (Borehole Image Processing System) av borrhålsväggarna.

Den dominerande bergarten i de karterade borrhålen KLX08, KLX09, KLX10 och KLX21B är ävrögranit, medan borrhålen KLX11A och KLX19A domineras av kvartsmonzodiorit. Enstaka finkornig diorit/gabbro förekommer i KLX08, KLX09, KLX19A och KLX21B. Små mängder av pegmatit gångar och ådror klippa endast i KLX19A, medan alla borrhålen uppvisar mindre mängder av klippande finkornig granit gångar och ådror.

Vattenförande krosszon förekommer endast i den hammarborrade delen av borrhål KLX19A.

Omvandling förekommer i form av rödfärgning (oxidering), för det mesta med svag intensitet, utom i KLX21B där oxidering av medel intensitet förekommer.

Denna rapport beskriver använd utrustning och genomförd aktivitet, observationer, leverans av data samt presentation och diskussion av resultaten.

Contents

1 Introduction

SKB, the Swedish Nuclear Fuel and Waste Management Company, performs site investigations in order to evaluate the feasibility of locating a deep repository for spent nuclear fuel /1/. The investigations are performed in the Swedish municipalities Östhammar and Oskarshamn.

Drilling and investigations in boreholes are fundamental activities in order to facilitate characterisation of rock and groundwater properties at depth. In the years 2004 to 2007 a total of nineteen deep cored boreholes were drilled within the Oskarshamn site investigation, in the Laxemar area /2/. Eighteen of those were constructed as "telescope holes", i.e. a upper section of the hole (normally ca 100 m) is percussion drilled and has a wider diameter than the deeper core drilled part of the hole /3, 4, 5, 6/. Eleven of these telescope holes were then logged with BIPS (Borehole Image Processing System), which is a high resolution, side viewing, colour borehole TV system /7, 8, 9, 10, 11, 12/. Six of the resulting BIPS images were of adequate quality for mapping according to the simplified Boremap mapping method.

This document reports data gained by simplified Boremap mapping of telescopic percussion boreholes KLX08, KLX09, KLX10, KLX11A, KLX19A and KLX21B located in the Laxemar subarea as shown in Figure 1-1. The work was carried out in accordance with activity plan AP PS 400-07-21. Table 1-1 lists the controlling documents for performing this activity. Both activity plan and method description are SKB internal controlling documents.

Mapping of the BIPS logged percussion boreholes is done according to the Simplified Boremap method, in accordance with method description SKB MD 143.006 (SKB internal document). Using the preliminary mapping of drill cuttings /3, 4, 5, 6/ for comparison, the Simplified Boremap mapping is based on the BIPS-image where both petrography (rock types, rock occurrences and alteration) and structures (open fractures, crush zones and ductile deformation) of the bedrock that the borehole cuts through can be determined. In addition the mapping software (Boremap) calculates the orientation (strike and dip) of each marked planar feature.

All data were stored in the primary data base SICADA for Oskarshamn and are traceable by the activity plan number.

The rock type nomenclature used is shown in Table 1-2.

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

Activity plan	Number	Version
Förenklad Boremapkartering av teleskopdelar för KLX08, KLX09, KLX10, KLX11A, KLX19A och KLX21B	AP PS 400-07-21	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för Boremap – kartering	SKB MD 143.006	2.0

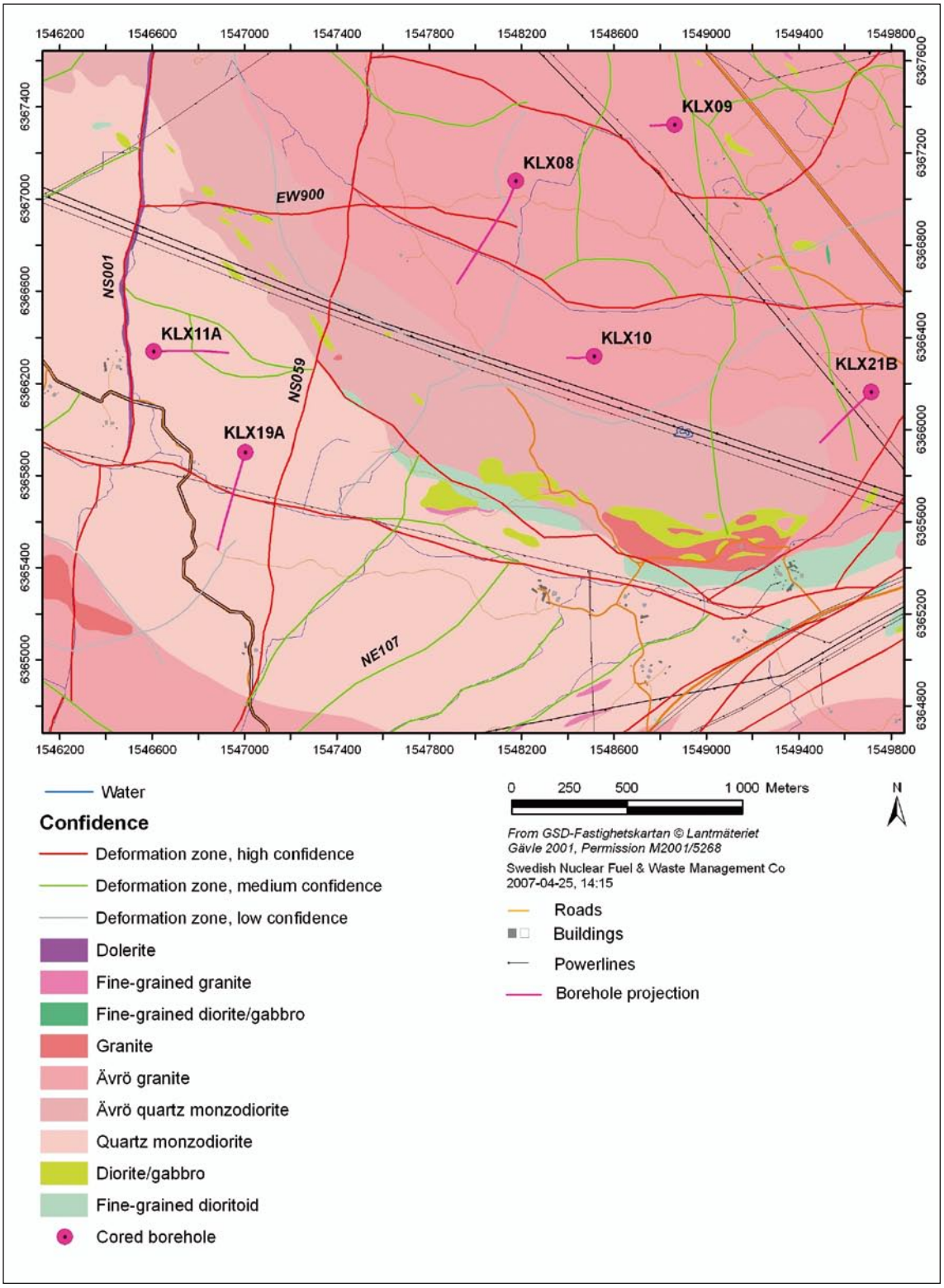

Figure 1-1. *Location of boreholes KLX08, KLX09, KLX10, KLX11A, KLX19A and KLX21B in the Laxemar subarea. The map shows the bedrock geology, linked lineaments, power lines, roads and houses.*

Table 1-2. Rock type nomenclature for the site investigation at Oskarshamn.

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, generally porphyritic
Ävrö quartz monzodiorite	501046	Quartz monzonite to quartz monzodiorite, generally porphyritic
Quartz monzodiorite	501036	Quartz monzonite to monzodiorite, equigranular to weakly porphyritic
Äspö diorite	501037	Quartz monzodiorite to granodiorite, porphyritic
Diorite/gabbro	501033	Diorite to gabbro
Fine-grained dioritoid	501030	Intermediate magmatic rock
Fine-grained diorite-gabbro	505102	Mafic rock, fine-grained
Greenstone	508107	Mafic rock, undifferentiated
Mylonite	508004	Mylonite
Sulphide mineralization	509010	Sulphide mineralization
Sandstone	506007	Sandstone

2 Objective and scope

The purpose of this survey is to map the lithology and structural parameters of percussion boreholes KLX08, KLX09, KLX10, KLX11A, KLX19A and KLX21B in greater detail than the preliminary mapping of drill cuttings and results of measurements made while drilling the percussion holes, by using the Simplified Boremap mapping method.

The mapped parameters of the Simplified Boremap mapping are:

- Rock types (> 1 m wide).
- Rock occurrences (> 0.2 to < 1 m wide).
- Rock contacts.
- Alteration (mainly the intensity of red staining).
- Open fractures (including crush zones).
- Ductile structures (e.g. foliation, shear zones etc).

3 Equipment

3.1 Description of equipment/interpretation tools

Mapping of BIPS-images according to the Simplified Boremap method is done on desktop computer using the software Boremap (version 3.9.2), which shows the BIPS-image as can be seen in Figure 3-1. Boremap is loaded with the SKB rock and mineral standard.

The accuracy of the Simplified Boremap mapping 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 on the borehole wall).
- The quality of the BIPS-image (i.e. the technical limitations of the image).

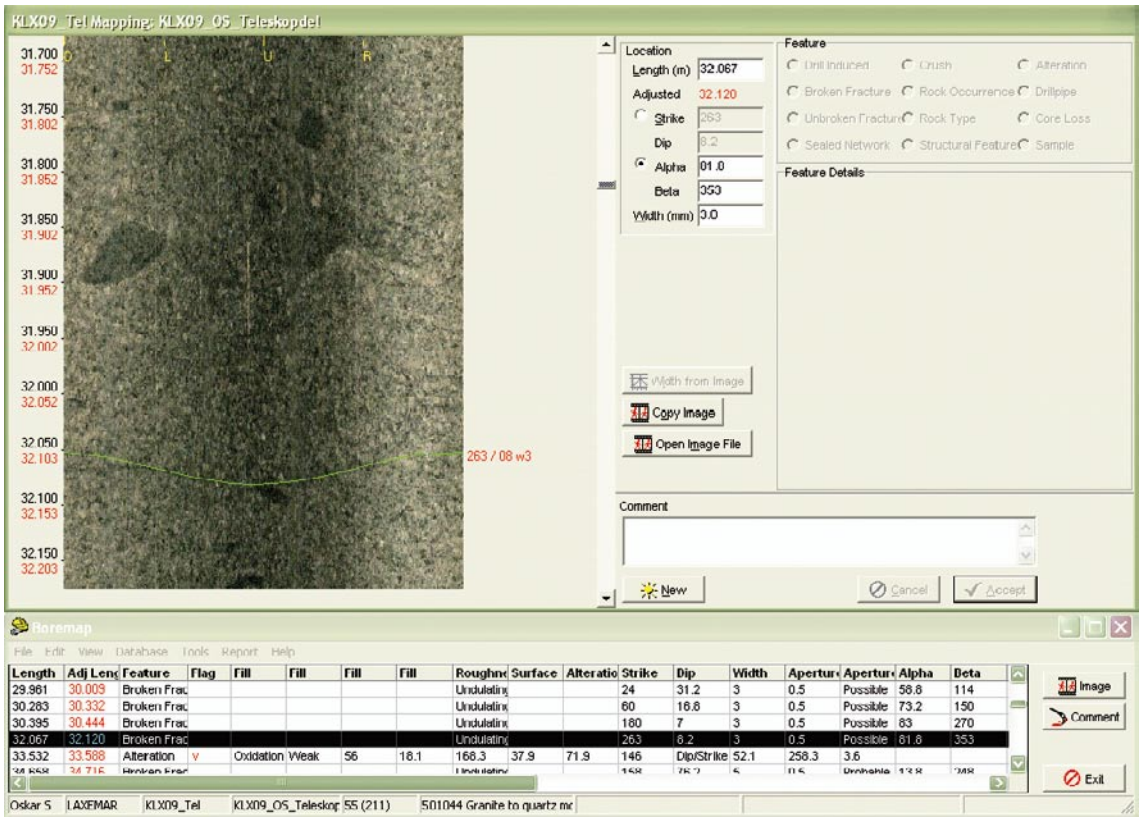

Figure 3-1. *Good quality BIPS-image as it is seen in Boremap. Borehole KLX09, showing grey, medium to coarse grained, massive, porphyritic Ävrö granite, with small fragments of fine-grained diorite-gabbro. Very thin layer of mud can be seen on bottom of borehole wall (lighter shade on right and left edges of image). Green line marks a probable open fracture at 32.12 m adjusted length.*

The BIPS-image quality of boreholes KLX08 is relatively dark /6/, while borehole KLX09 shows very good quality /7/, KLX10 is medium to somewhat dark /8/, KLX11A is generally of good quality although a bit dark /9/, KLX19A is also of good quality except for some mud in suspension at certain depths /10/ and KLX21B is somewhat dark /11/. The general darkness of the BIPS images in the telescopic boreholes is a result of the limited strength of light in the camera in combination with the larger diameter of the holes and the general darkness of the rock /9/.

For closer examination of drill cuttings normal field geologist equipment was used; a hand held lens, streak plate (a piece of white, unglazed porcelain), small magnet, hydrochloric acid (HCl 10% solution) and a knife. A stereomicroscope Zeiss Stemi DV 4 (magnification 8X-32X) was used when necessary. Susceptibility meter SM20 from GF instruments was used for measurements of the magnetic susceptibility in the drill cuttings.

4 Execution

4.1 General

Simplified Boremap mapping is comprised of data from:

- BIPS-image /6, 7, 8, 9, 10, 11/,
- preliminary mapping of drill cuttings /3, 4, 5, 6/,
- results from percussion drilling /3, 4, 5, 6/,
- available geophysical measurements and interpretations /13, 14, 15, 16, 17/.

The BIPS-image is opened in Boremap where the observed appropriate parameters are marked and described. To increase the accuracy of the mapping comparisons are made with preliminary mapping of drill cuttings, drilling penetration rate and when available results from geophysical measurements and interpretations.

4.2 Preparations

Data from the SKB database SICADA used for Simplified Boremap mapping is listed in Table 4-1. The length of the BIPS-image is adjusted from bottom of casing, to bottom of image according to a constant (the measured length registered in the BIPS-image deviates from the true length by a factor of approximately 0.5 m per 100 m) or top of the conical adapter /3, 4, 5, 6/.

The orientation of the borehole i.e. the azimuth and dip are the basis for calculating the strike and dip of the mapped planar structures. Data from deviation measurements with "Easy-shot", Flexit and Maxibor were used to correct for changes in direction of the boreholes with length /3, 4, 5, 6/.

Table 4-1. Borehole data for KLX08, KLX09, KLX10, KLX11A, KLX19A and KLX21B (values from top of casing). Data taken from SKB database SICADA and Boremap (adjusted length).

ID-code	Northing	Easting	Bearing (degrees)	Inclin-ation (degrees)	Dia-meter (mm)	Top of cone (m)	End of casing (m)	BIPS-image interval, adj. length (m)
KLX08	6367079.10	1548176.71	199.17	–60.25	197	96.15	12.20	12.00–96.66
KLX09	6367323.45	1548863.18	267.41	–85.29	197	97.33	11.95	11.00–97.72
KLX10	6366319.38	1548515.23	205.81	–85.19	197	97.48	12.10	12.00–98.11
KLX11A	6366339.72	1546608.49	89.84	–76.43	195	96.08	12.05	12.00–96.61
KLX19A	6365901.42	1547004.62	197.13	–57.78	253	96.03	6.30	6.30–98.15
KLX21B	6366164.00	1549715.10	225.05	–70.86	198	96.15	11.85	11.00–98.25

4.3 Execution of field work

BIPS-images make it possible to map features in percussion boreholes that are not discernible using rock cuttings and/or geophysical measurements. Planar structures such as open fractures, rock contacts, and deformational structures can be mapped accurately.

Below is a list of the parameters that are mapped with a short description and explanations for the WellCAD representation in Appendix 1–6:

- Lithology. Rock contacts, rock types (> 1 m wide) and rock occurrences (> 0.2 to < 1 m wide).
  - The lithological classification is sometimes difficult in the drill cuttings because of small fragment size of drill cuttings and the sometimes strong red staining/oxidation of the rock, but usually not a problem when drill cuttings and good quality BIPS-image can be compared.
  - Rock structure, texture and grain size is easily discerned in good quality BIPS-images, especially in medium to coarse grained rocks, while finer grained rocks often need to be seen in the drill cuttings. The WellCAD presentation shows these parameters for the rock types only, although they are also mapped for the rock occurrences.
  - Sharp rock contacts are easily mapped, but diffuse and undulating contacts of e.g. veins are often approximations. Rock contacts are shown as horizontal lines in the Well CAD presentations, regardless of their true orientation.
- Alteration and alteration intensity.
  - The only rock alteration that is mapped with some certainty in good quality BIPS-images are the red staining of the rock (oxidation) and its intensity. Other alterations are normally difficult to identify in the BIPS-image, but can sometimes be recognized in the drill cuttings.
- Open fractures and crush zones.
  - Only fractures that seemingly show apertures in the BIPS-image are mapped. Their apparent aperture is measured in the image, if a fracture is less than 1 mm wide it is assigned an aperture of 0.5 mm (Open Fracture Aperture).
  - Roughness of open fractures is determined as planar, undulating or stepped and represented as coloured lines (Open Fracture Roughness).
  - The alteration intensity of open fractures are determined and represented as coloured dots (Open Fracture Alteration) in the WellCAD presentation. The strike and dip of each fracture is represented with the coloured dot marking the dip (0–90 degrees) and a short line pointing to the direction (0–360 degrees).
  - The number of open fractures is calculated by the software for each meter and represented in the column Open Fracture Frequency (fr/m).
  - Crush zones are also mapped from the BIPS-image, the average size of fragments is measured in mm (Natural Piece Size) and the alteration intensity is decided. The colouring is the same as the Open Fracture Alteration in the WellCAD representation. Two interpreted main fracture directions are also marked within each crush zone in the BIPS-images.

4.4 Data handling/post processing

The Simplified Boremap mapping of the percussion boreholes is performed on a local computer disk at the core storage facility and saved on back-up in SKB internal network. When a borehole has been mapped the file is quality checked by the author and by a computer routine in Boremap. The data is then submitted to SKB for exportation to SICADA

4.5 Nonconformities

No formal nonconformities have been registered during the activity.

5 Results

Below the results from mapping of lithology, alteration and open fractures are given for boreholes KLX08, KLX09, KLX10, KLX11A, KLX19A and KLX21B. The percentages of different lithologies are given in Tables 5-1 through 5-6. The amount of alteration (red staining/ oxidation) as well as their intensity is listed in Table 5-7, while the number of open fractures and the average fracture frequency per meter can be seen in Table 5-8, and finally the crush zones mapped from the BIPS-image are listed in Table 5-9.

KLX08

See Appendix 1 for WellCAD presentation of mapping results.

Lithology: The dominant rock type is Ävrö granite carrying small amounts of fine-grained diorite-gabbro, see Figure 5-1, all cut by minor dykes and veins of fine-grained granite, see Table 5-1.

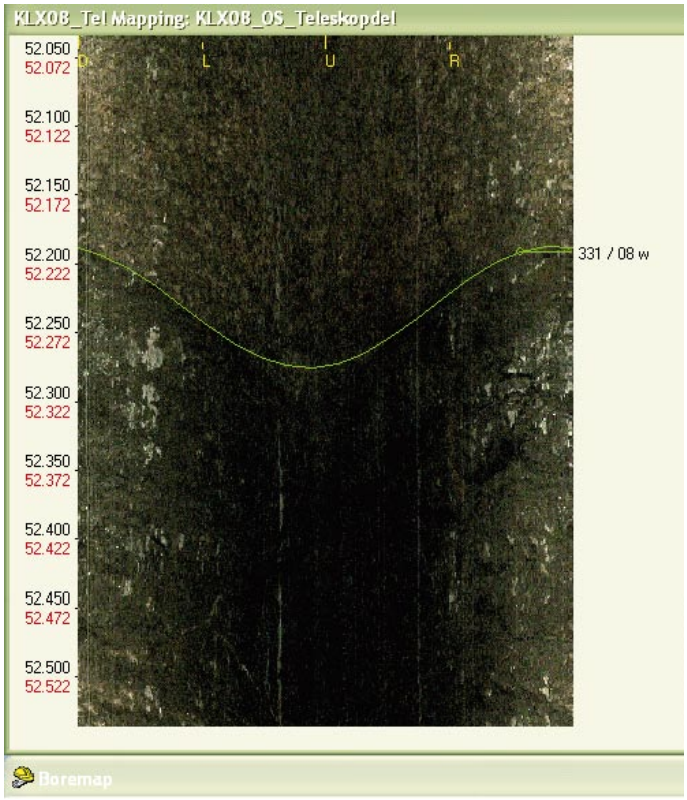

Figure 5-1. *BIPS-image as seen in Boremap, showing contact between Ävrö granite and fine-grained diorite/gabbro in borehole KLX08. Visibility is poor (dark image), the green line marks the rock contact.*

Table 5-1. Lithology of KLX08. Percents calculated from adjusted length of BIPS-image.

Rock name	SKB rock code	%
Ävrö granite	501044	94.7
Fine-grained diorite-gabbro	505102	2.8
Fine-grained granite	511058	2.5

Alteration: Alteration in the form of red staining (oxidation) occurs, in total ca 47% see Table 5-7 and Appendix 1. It is somewhat uncertain because of the darkness of the image, but seems more common in lower part of hole (see Appendix 1).

Open fractures: Mapped open fractures are 194, resulting in an average of 2.31 per meter, see Table 5-8. No crush zones were observed in the BIPS-image.

KLX09

See Appendix 2 for WellCAD presentation of mapping results.

Lithology: The dominant rock types is Ävrö granite carrying minor amounts of fine-grained diorite/gabbro, see Figure 3-1, all cut by dykes and veins of fine-grained granite, see Figure 5-2 and Table 5-2.

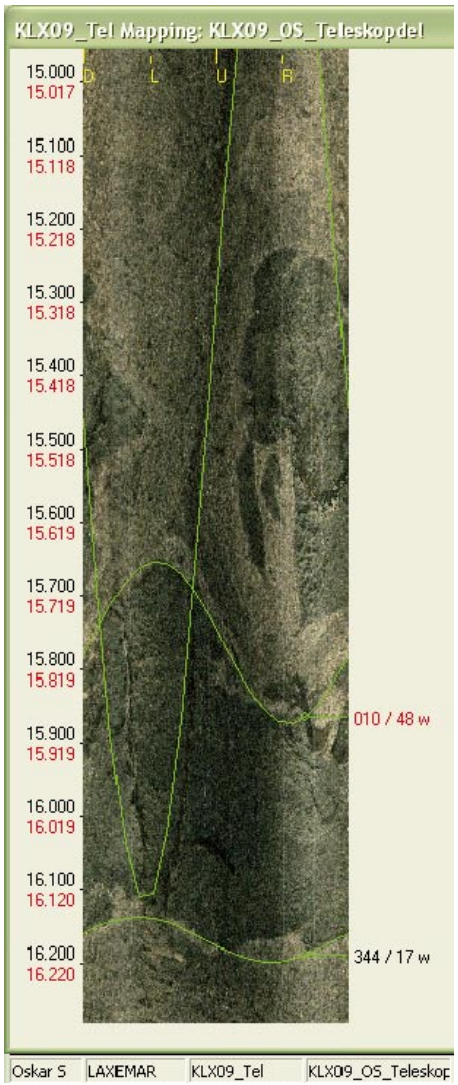

Figure 5-2. *BIPS-image as seen in Boremap, showing fine-grained granite cutting up a fine-grained diorite/gabbro in borehole KLX09. Lower two green lines mark rock contact (15.8–16.2 m adjusted length), while the long green line marks possible open fracture at 15.4 m (adjusted length).*

Table 5-2. Lithology of KLX09. Percents calculated from adjusted length of BIPS-image.

Rock name	SKB rock code	%
Ävrö granite	501044	85.5
Fine-grained diorite-gabbro	505102	9.5
Fine-grained granite	511058	4.9

Alteration: Alteration in the form of red staining (oxidation) occurs, in total 43%, see Table 5-7 and Appendix 2. Oxidation seems to increase somewhat in lower part of hole, see Appendix 2.

Open fractures: Mapped open fractures are 153, resulting in an average of 1.79 per meter, see Table 5-8. No crush zones were observed in the BIPS-image, but some increase in fracture frequency occurs in lower part of hole, see Appendix 2.

KLX10

See Appendix 3 for WellCAD presentation of mapping results.

Lithology: The dominant rock type is Ävrö granite cut by a dyke/vein of fine-grained granite, see Figure 5-3 and Table 5-3.

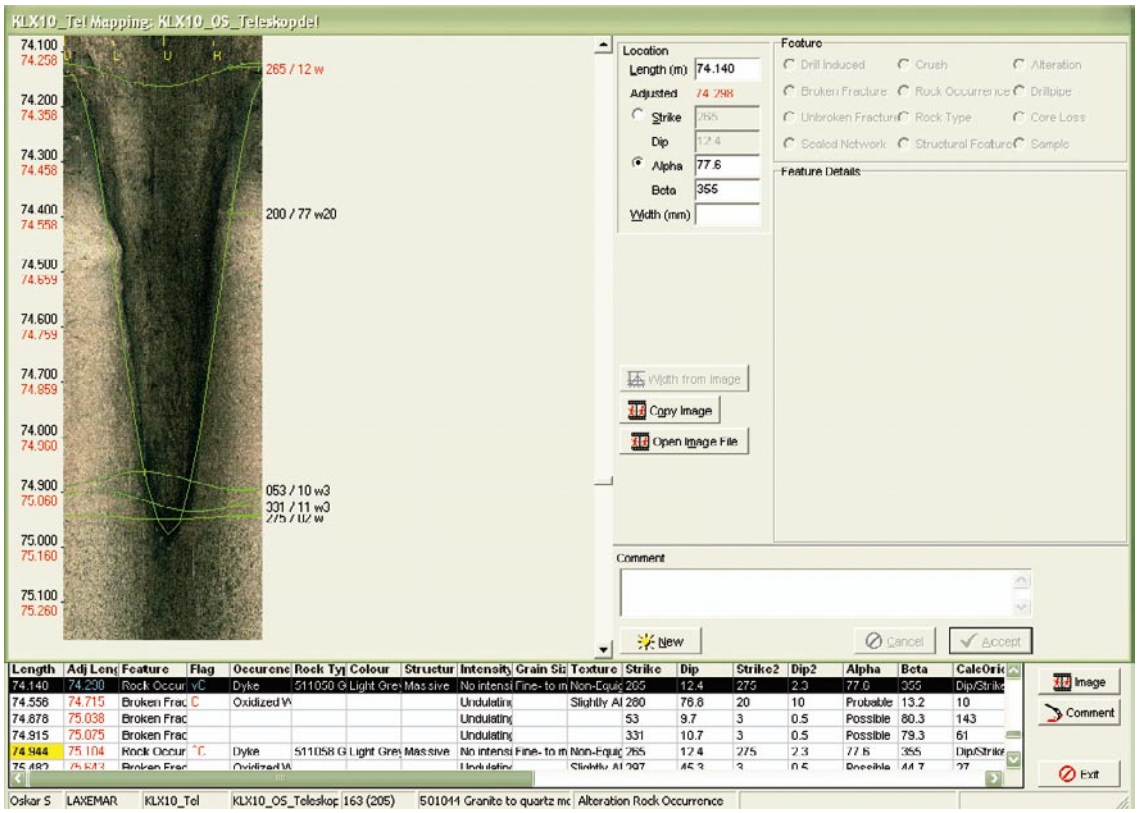

Figure 5-3. BIPS-image of borehole KLX10 as seen in Boremap, is dominated by an open fracture at 74.72 m (adjusted length) with a measured inflow of water of ca 24 l/min. Green lines also mark the contact between Ävrö granite and fine-grained granite at ca 74.30 and 75.10 m (adjusted length). Two possible open fractures occur at bottom of fine-grained granite (75.01 and 75.08 m, adjusted length).

Table 5-3. Lithology of KLX10. Percents calculated from adjusted length of BIPS-image.

Rock name	SKB rock code	%
Ävrö granite	501044	99.1
Fine-grained granite	511058	0.9

Alteration: Alteration in the form of red staining (oxidation) occurs the whole length of the drilling, in total ca 100%, see Table 5-7 and Appendix 3.

Open fractures: Mapped open fractures are 200, resulting in an average of 2.34 per meter, see Table 5-8. No crush zones were observed in the BIPS-image. One open fracture with water inflow of ca 24 l/min occurs at 74.72 m (adjusted length), see Figure 5-3. Fracture frequency seems to diminish somewhat down hole, see Appendix 3.

KLX11A

See Appendix 4 for WellCAD presentation of mapping results.

Lithology: The dominant rock type is quartz monzodiorite cut by occasional dykes and veins of fine-grained granite, see Table 5-4 and Figure 5-4.

Alteration: Alteration in the form of red staining (oxidation) occurs, in total ca 14%, see Table 5-7 as well as Appendix 4.

Open fractures: Mapped open fractures are 79, resulting in an average of 0.93 per meter, see Table 5-8. No crush zones were observed in the BIPS-image.

Table 5-4. Lithology of KLX11A. Percents calculated from adjusted length of BIPS-image.

Rock name	SKB rock code	%
Quartz monzodiorite	501036	98.7
Fine-grained granite	511058	1.3

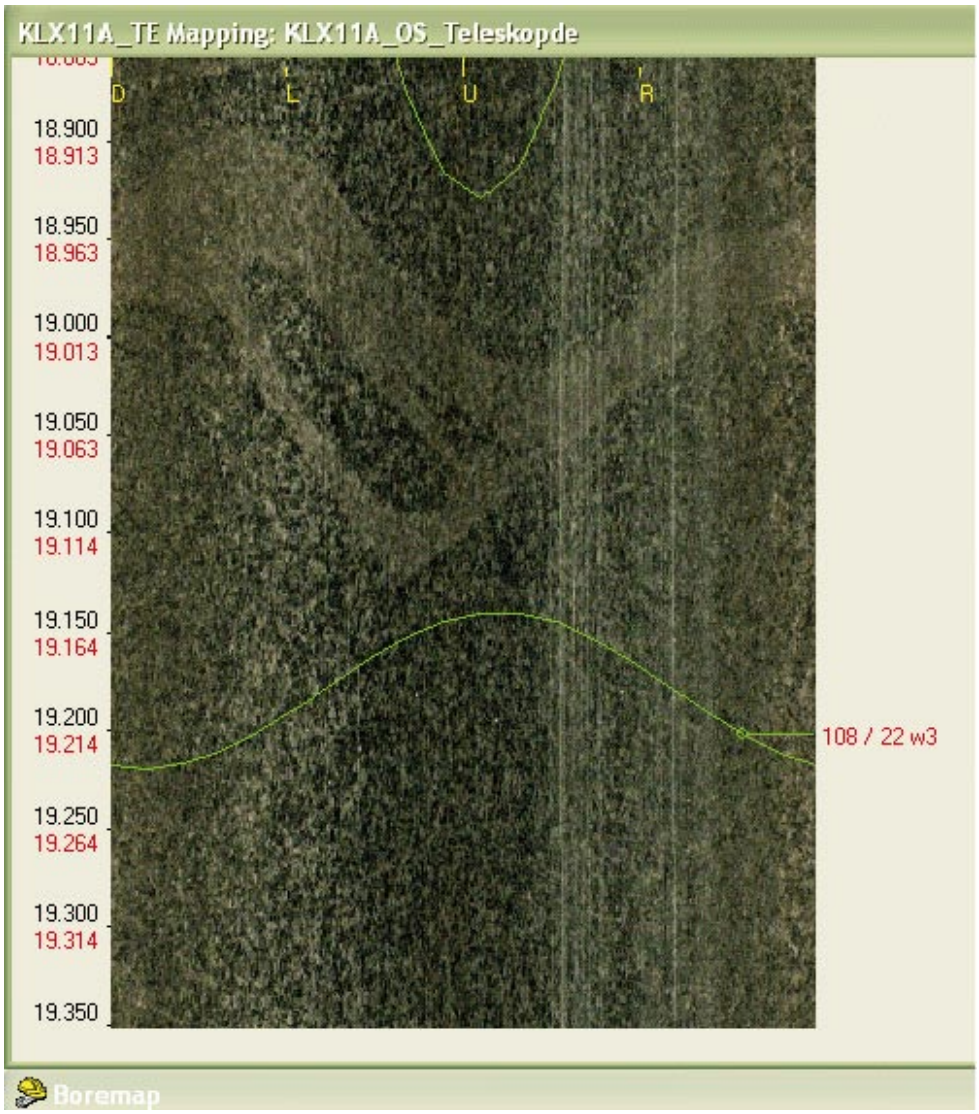

Figure 5-4. *BIPS-image as seen in Boremap, showing quartz monzodiorite cut by a thin vein of fine-grained granite in borehole KLX11A. Green line marks a possible open fracture at 19.19 m (adjusted depth).*

KLX19A

See Appendix 5 for WellCAD presentation of mapping results.

Lithology: The dominant rock type is quartz monzodiorite with minor amounts of fine grained diorite-gabbro, all is cut by dykes and veins of fine-grained granite and to a lesser extent pegmatite, see Table 5-5 and Figure 5-5.

Table 5-5. Lithology of KLX19A. Percents calculated from adjusted length of BIPS-image.

Rock name	SKB rock code	%
Quartz monzodiorite	501036	87.9
Fine-grained granite	511058	10.3
Pegmatite	501061	1.0
Fine-grained diorite-gabbro	505102	0.8

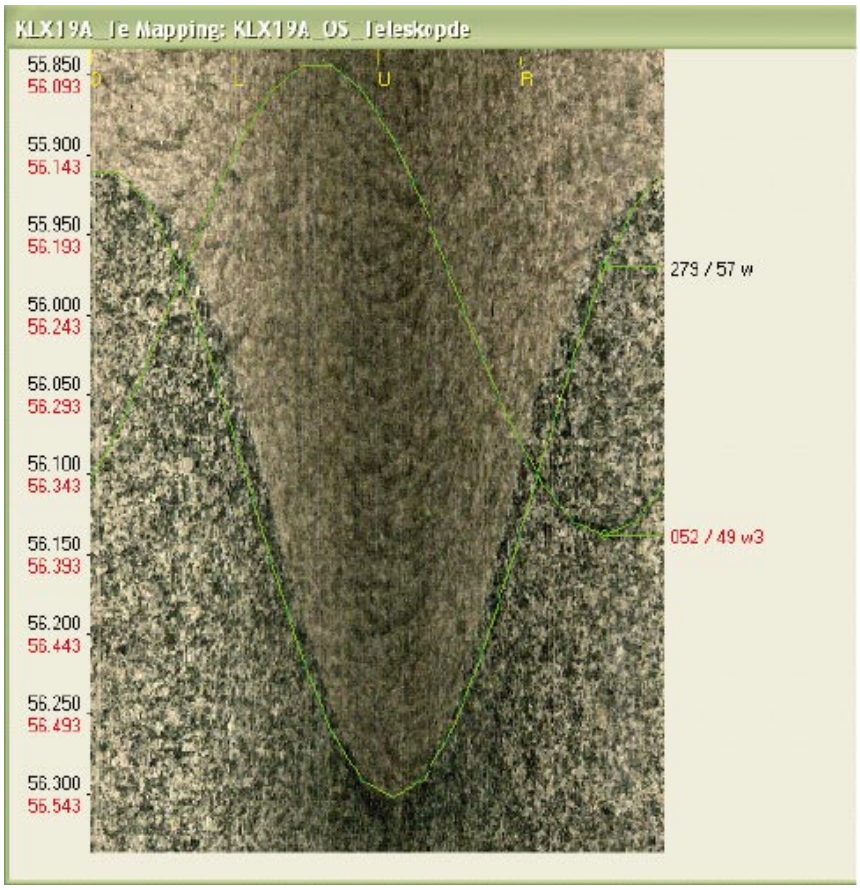

Figure 5-5. *BIPS-image as seen in Boremap, green line (279/57w) marks the lower contact between quartz monzodiorite and fine-grained granite in borehole KLX19A at ca 56.35 m (adj. length). Green line (052/49w3) marks a probable open fracture at 56.23 m (adjusted length).*

Alteration: Alteration in the form of red staining (oxidation) occurs, in total ca 31.3%, see Table 5-7 and Appendix 5.

Open fractures: Mapped open fractures are 127, resulting in an average of 1.38 per meter, see Table 5-8. One crush zone is marked, at ca 51.5 m (adjusted length), with measured water inflow of ca 64 l/min, see Figure 5-6 and Table 5-9. Fracture frequency is somewhat higher for approximately 10 m following the crush zone, see Appendix 5.

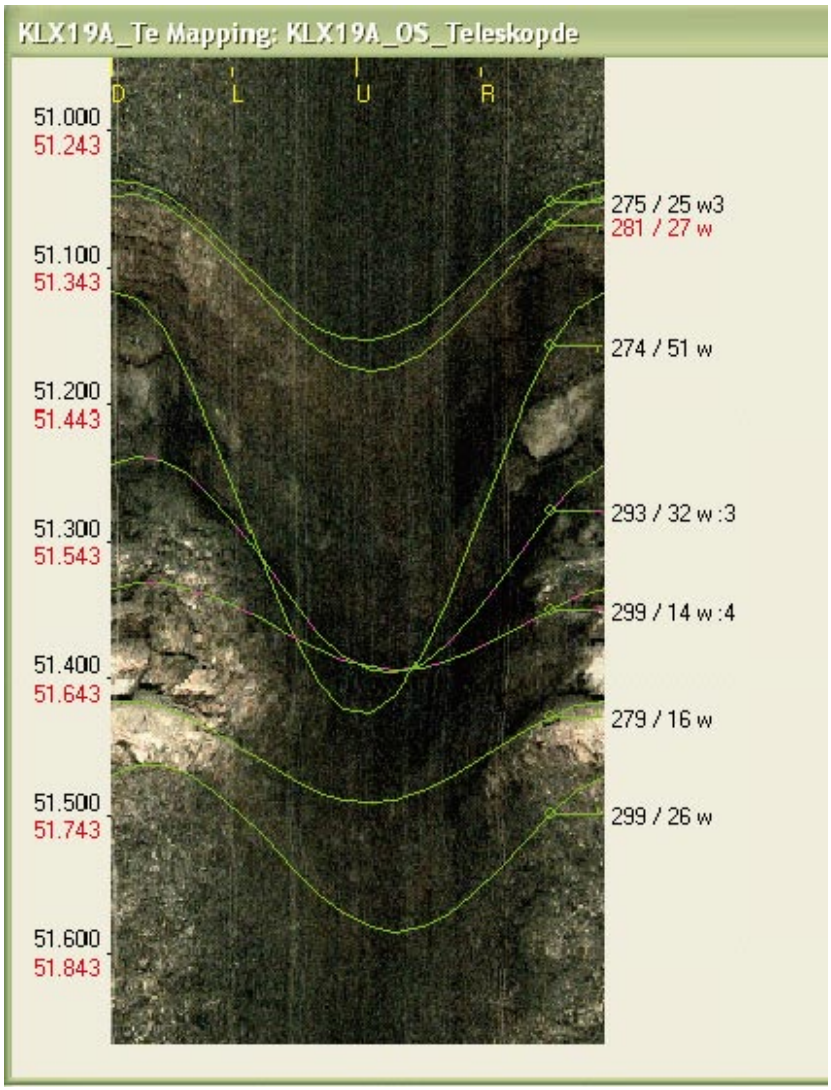

Figure 5-6. *BIPS-image as seen in Boremap from borehole KLX19A, showing a water yielding crush zone at 51.51–51.70 m (adj. length) in pegmatite dyke, contacts with the quartz monzodiorite are at 51.35 and 51.77 m (adj. length) just outside the crush zone. Green lines mark rock contacts, crush zone with two main fracture directions and probable open fractures.*

KLX21B

See Appendix 6 for WellCAD presentation of mapping results.

Lithology: The dominant rock types is Ävrö granite carrying minor amounts of fine-grained diorite/gabbro, all cut by dykes and veins of fine-grained granite, see Table 5-6 and Figure 5-7.

Table 5-6. Lithology of KLX21B. Percents calculated from adjusted length of BIPS-image.

Rock name	SKB rock code	%
Ävrö granite	501044	92.2
Fine-grained granite	511058	4.4
Fine-grained diorite/gabbro	505102	3.4

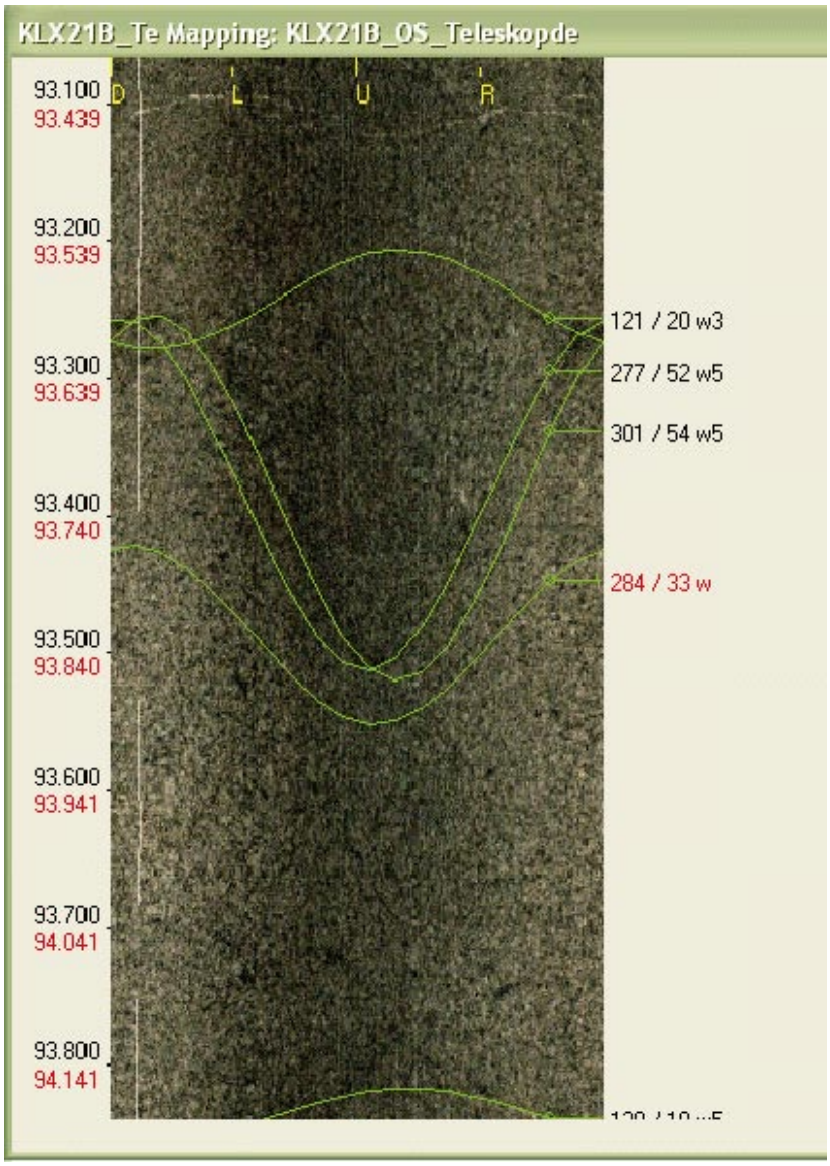

Figure 5-7. *BIPS-image as seen in Boremap, showing weakly oxidized Ävrö granite above the green line at 93.83 m (adjusted length) in borehole KLX21B. Green lines indicate probable open fractures.*

Alteration: Alteration in the form of red staining (oxidation) occurs often, in total ca 91.5%, see Figure 5-7, Table 5-7 and Appendix 5. Between approximately 64–82 m the alteration is of medium intensity, see Appendix 5.

Open fractures: Mapped open fractures are 190, resulting in an average of 2.25 per meter, see Table 5-8. No crush zones were observed in the BIPS-image. The fracture frequency in the borehole is somewhat higher in the lower part of and just below the medium intensity alteration, see Appendix 6.

Table 5-7. Total alteration in percussion boreholes KLX08, KLX09, HLX10, KLX11A, KLX19A and KLX21B.

Alteration	Intensity	KLX08 (%)	KLX09 (%)	KLX10 (%)	KLX11A (%)	KLX19A (%)	KLX21B (%)
Oxidation	**Weak**	47	39	100	14	31	70
	Medium	–	4	–	–	–	22

Table 5-8. Total number of open fractures in percussion boreholes KLX08, KLX09, HLX10, KLX11A, KLX19A and KLX21B.

	Total number of open fractures	Fractures/ meter
KLX08	194	2.3
KLX09	153	1.8
KLX10	200	2.3
KLX11A	79	0.9
KLX19A	127	1.4
KLX21B	190	2.3

Table 5-9. Mapped crush zones in percussion boreholes KLX08, KLX09, HLX10, KLX11A, KLX19A and KLX21B. Strike/Dip from top of crush zone.

Borehole ID	Adjusted length (m)	Total width of zone (m)	Piece length (m)	Strike/Dip (degrees)
KLX08	–	–	–	–
KLX09	–	–	–	–
KLX10	–	–	–	–
KLX11A	–	–	–	–
KLX19A	51.51	0.19	0.65	274/51
KLX21B	–	–	–	–

6 Summary and discussions

In addition to the boreholes described in this report boreholes KLX06, KLX07, KLX12A, KLX13A and KLX17A were also logged with BIPS, but they were of such poor quality that they were not mapped in Boremap.

The lithology dominating KLX08, KLX09, KLX10 and KLX21B is Ävrö granite (see Tables 5-1 to 5-3 and 5-6). All except KLX10 carry minor amounts of fine-grained diorite-gabbro and all are cut by occasional fine-grained granite dykes and veins (see Tables 5-1 to 5-3 and 5-6). Red staining (oxidation) occurs in approximately 45% of the rock in KLX08 and KLX09, although the dark BIPS image of KLX08 makes the determination somewhat uncertain. All the rock in KLX10 shows red staining as well as most of KLX21B, where approximately 20% is more strongly altered, see Table 5-7. No crush zones were noted in the telescopic part of the boreholes, see Table 5-9. One open fracture with water inflow of ca 24 l/min occurs at 74.72 m (adjusted length) in borehole KLX10, see Figure 5-3.

On the other hand the lithology dominating KLX11A and KLX19A is quartz monzodiorite cut by minor amounts of fine-grained granite dykes and veins (see Tables 5-4 and 5-5). In KLX19A minor amounts of fine-grained diorite-gabbro and a few cutting pegmatite dykes occur also (see Table 5-5). Both show little red staining (oxidation), see Table 5-7. One distinct water yielding crush zone occurs in KLX19A at ca 51.5 m borehole length (see Table 5-9 and Figure 5-6), while KLX11A shows no crush zones or inflow of water, see Table 5-9.

The parameters not represented in the WellCAD representations are either uncommon or difficult to map from the BIPS-image. As an example fracture minerals which sometimes occur in open fractures are all labelled as unknown mineral, because of the difficulties in identifying them accurately from the BIPS-image. In the rock cuttings secondary minerals are identified when possible, e.g. epidote and calcite, but can normally not be assigned to a specific fracture. Only one alteration type of open fractures is identified in good quality BIPS-image i.e. red colouring of rims, but they can rarely be verified in the rock cuttings.

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Simplified geology KLX08

Title SIMPLIFIED GEOLOGY KLX08 **Appendix**

Site	LAXEMAR	**Coordinate System**	RT90-RHB70
Borehole	KLX08	**Northing [m]**	6367079.10
Diameter [mm]	76	**Easting [m]**	1548176.71
Length [m]	1000.410	**Elevation [m.a.s.l.]**	24.31
Bearing [°]	199.17	**Drilling Start Date**	2005-01-12 14:00:00
Inclination [°]	-60.50	**Drilling Stop Date**	2005-01-24 18:30:00
Date of mapping	2007-02-21 11:07:00	**Plot Date**	2008-05-08 22:05:17
		Signed data	

ROCKTYPE LAXEMAR
- Fine-grained granite
- Ävrö granite
- Fine-grained diorite-gabbro

ROCK STRUCTURE
- Massive

ROCK ALTERATION
- Oxidized

INTENSITY
- Weak

ROCK TEXTURE
- Porphyritic
- Equigranular
- Unequigranular

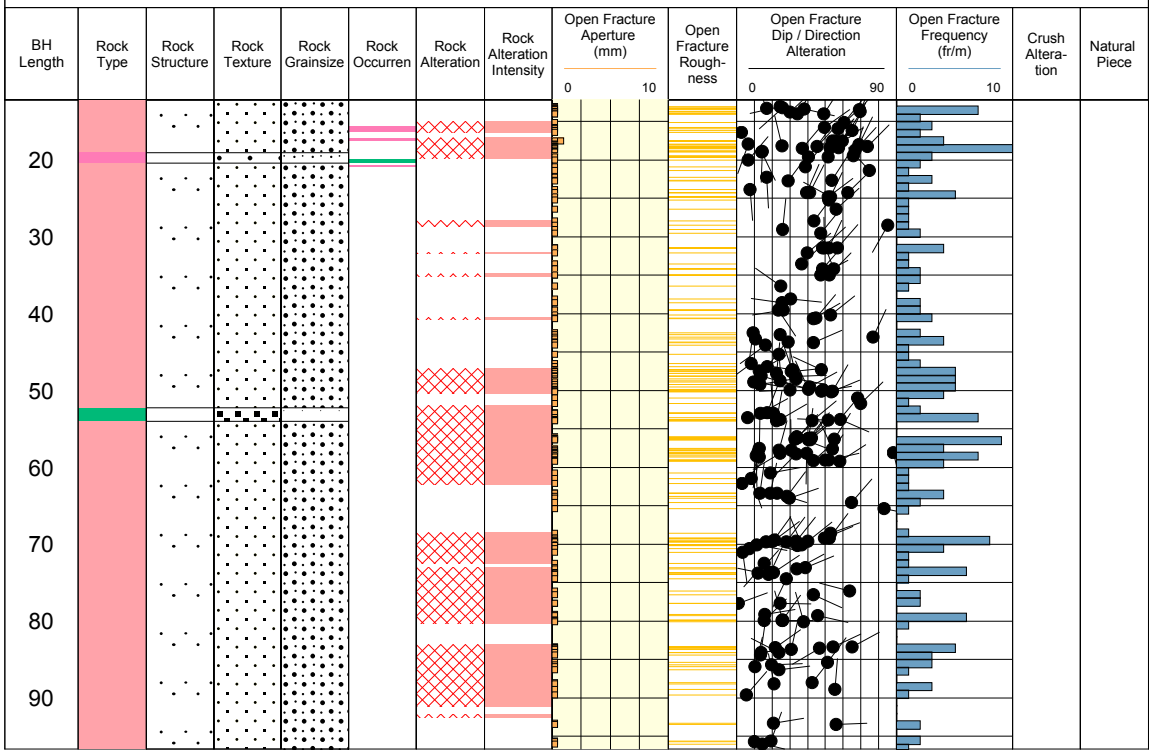
FRACTURE ALTERATION

ROUGHNESS
- Undulating

ROCK OCCURRENCE
- Fine-grained granite
- Fine-grained diorite-gabbro

ROCK GRAINSIZE
- Fine-grained
- Fine to medium grained
- Medium to coarse grained

SIMPLIFIED BOREMAP MAPPING



Simplified geology KLX09

Title SIMPLIFIED GEOLOGY KLX09 **Appendix**

Site	LAXEMAR	**Coordinate System**	RT90-RHB70
Borehole	KLX09	**Northing [m]**	6367323.45
Diameter [mm]	76	**Easting [m]**	1548863.18
Length [m]	880.380	**Elevation [m.a.s.l.]**	23.45
Bearing [°]	267.41	**Drilling Start Date**	2005-06-02 13:00:00
Inclination [°]	-84.93	**Drilling Stop Date**	2005-06-13 17:30:00
Date of mapping	2007-02-22 09:54:00	**Plot Date**	2008-05-08 22:05:17
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ROCKTYPE LAXEMAR
- Fine-grained granite
- Ävrö granite
- Fine-grained diorite-gabbro

ROCK STRUCTURE
- Massive

ROCK ALTERATION
- Oxidized

INTENSITY
- Weak
- Medium

FRACTURE ALTERATION

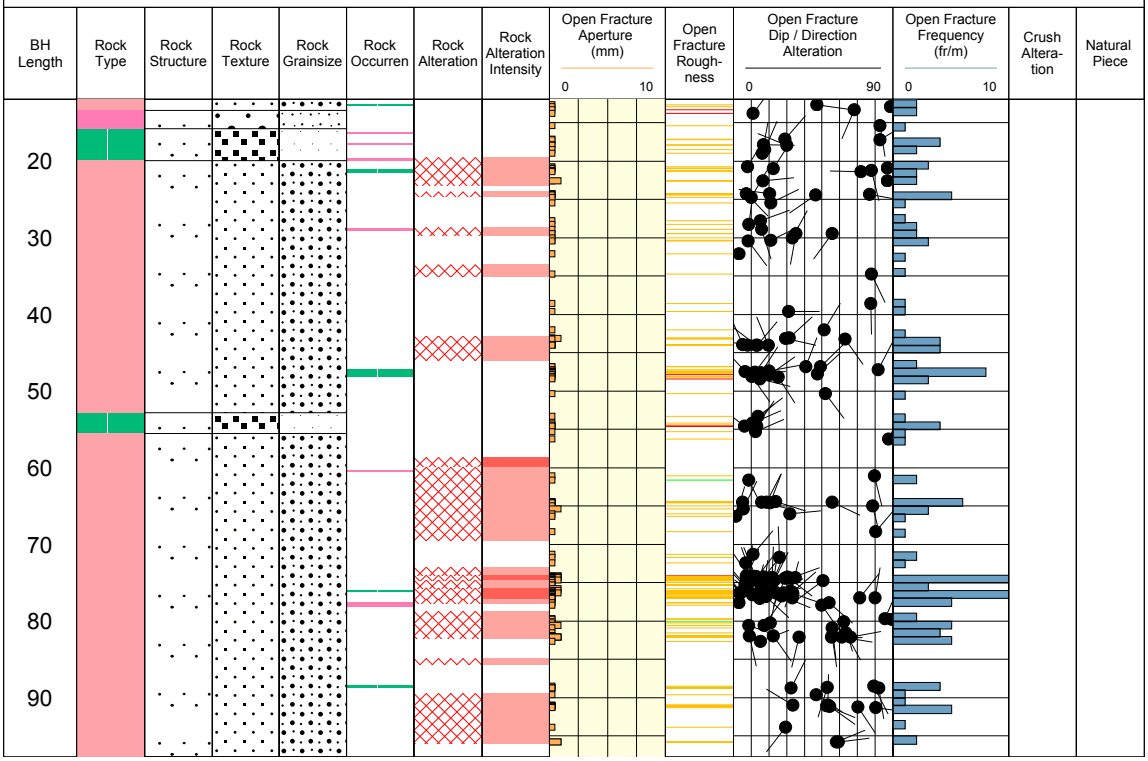
ROCK TEXTURE
- Porphyritic
- Equigranular
- Unequigranular

ROUGHNESS
- Planar
- Undulating
- Stepped

ROCK OCCURRENCE
- Fine-grained granite
- Fine-grained diorite-gabbro

ROCK GRAINSIZE
- Fine-grained
- Fine to medium grained
- Medium to coarse grained

SIMPLIFIED BOREMAP MAPPING



Simplified geology KLX10

Title SIMPLIFIED GEOLOGY KLX10 **Appendix**

Site	LAXEMAR	**Coordinate System**	RT90-RHB70
Borehole	KLX10	**Northing [m]**	6366319.38
Diameter [mm]	76	**Easting [m]**	1548515.23
Length [m]	1001.200	**Elevation [m.a.s.l.]**	18.28
Bearing [°]	250.80	**Drilling Start Date**	2005-05-24 12:30:00
Inclination [°]	-85.18	**Drilling Stop Date**	2005-06-01 16:45:00
Date of mapping	2007-02-28 14:18:00	**Plot Date**	2008-05-08 22:05:17
		Signed data	

ROCKTYPE LAXEMAR
Ävrö granite

ROCK STRUCTURE
Massive

ROCK ALTERATION
Oxidized

INTENSITY
Weak

ROCK TEXTURE
Porphyritic

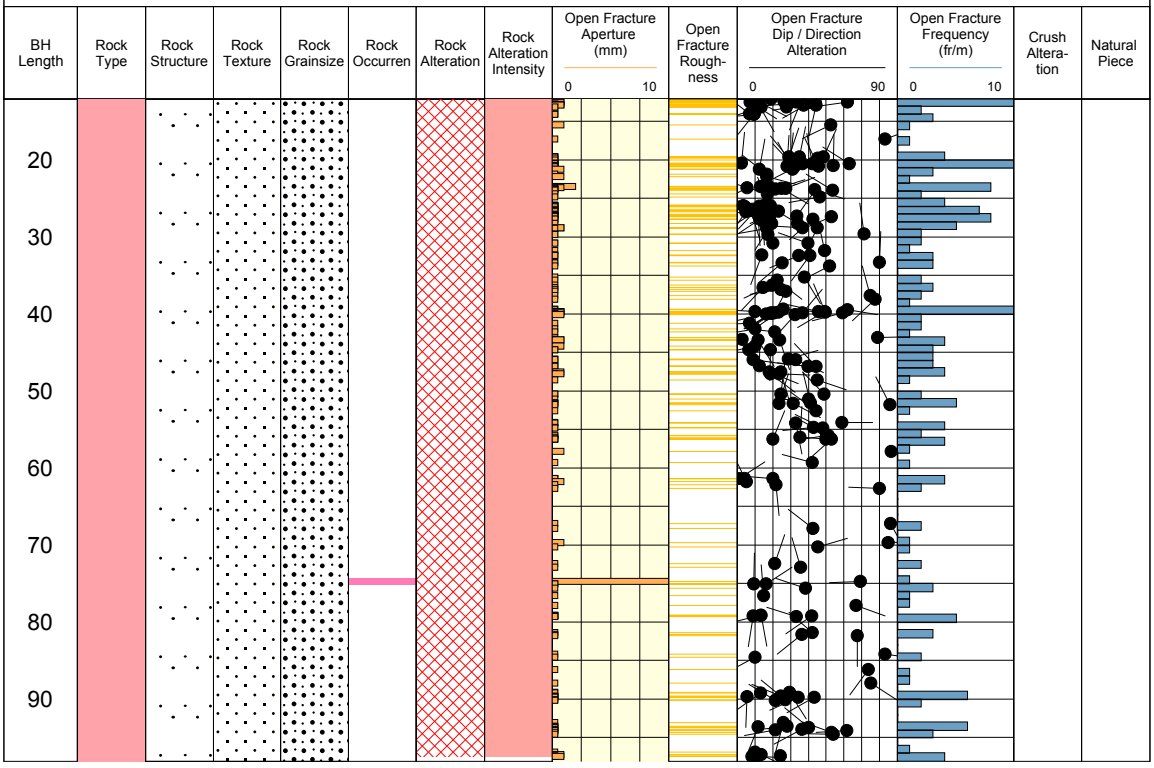
FRACTURE ALTERATION

ROUGHNESS
Undulating

ROCK OCCURRENCE
Fine-grained granite

ROCK GRAINSIZE
Medium to coarse grained

SIMPLIFIED BOREMAP MAPPING



Simplified geology KLX11A

Title SIMPLIFIED GEOLOGY KLX11A **Appendix**

Site	LAXEMAR	**Coordinate System**	RT90-RHB70
Borehole	KLX11A	**Northing [m]**	6366339.72
Diameter [mm]	76	**Easting [m]**	1546608.49
Length [m]	992.290	**Elevation [m.a.s.l.]**	27.14
Bearing [°]	89.84	**Drilling Start Date**	2005-11-01 07:00:00
Inclination [°]	-76.76	**Drilling Stop Date**	2005-11-08 10:30:00
Date of mapping	2007-03-13 08:48:00	**Plot Date**	2008-05-08 22:05:17
		Signed data	

ROCKTYPE LAXEMAR
Quartz monzodiorite

ROCK STRUCTURE
Massive

ROCK ALTERATION
Oxidized

INTENSITY
Weak

ROCK TEXTURE
Equigranular

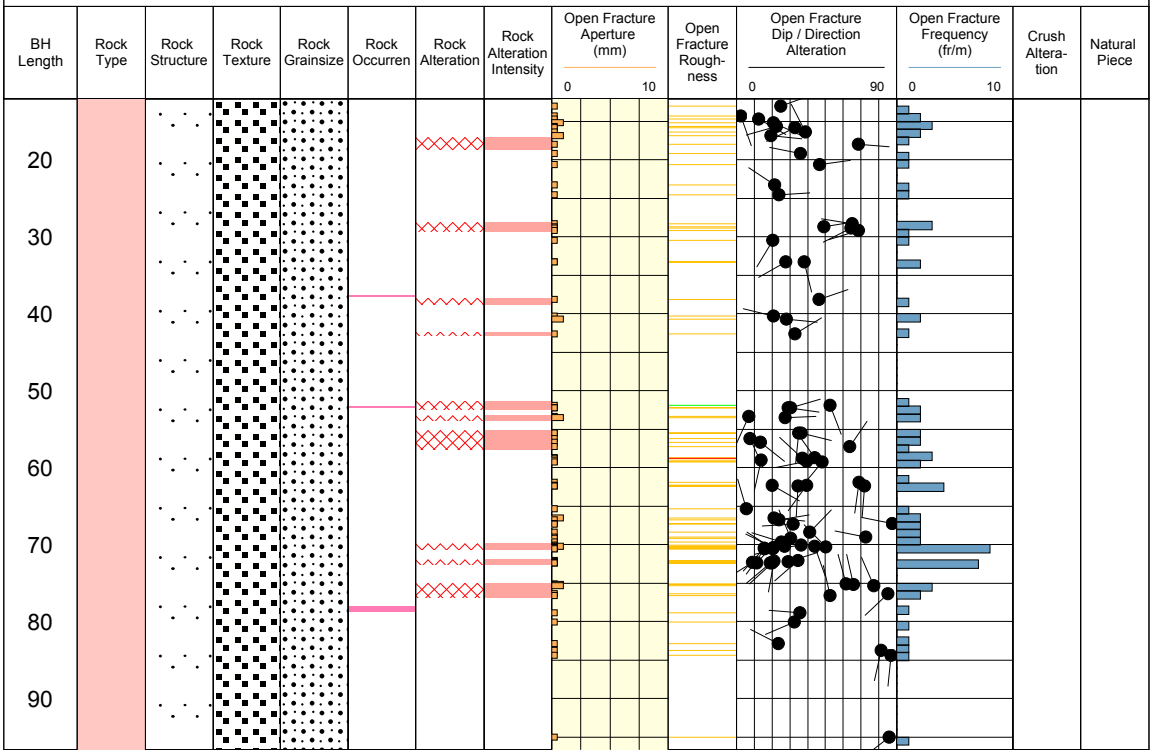
FRACTURE ALTERATION

ROUGHNESS
Planar
Undulating
Stepped

ROCK OCCURRENCE
Fine-grained granite

ROCK GRAINSIZE
Medium to coarse grained

SIMPLIFIED BOREMAP MAPPING



Simplified geology KLX19A

Title SIMPLIFIED GEOLOGY KLX19A **Appendix**

Site	LAXEMAR	**Coordinate System**	RT90-RHB70
Borehole	KLX19A	**Northing [m]**	6365901.42
Diameter [mm]	76	**Easting [m]**	1547004.62
Length [m]	800.070	**Elevation [m.a.s.l.]**	16.87
Bearing [°]	197.13	**Drilling Start Date**	2006-05-10 16:30:00
Inclination [°]	-57.54	**Drilling Stop Date**	2006-05-22 12:00:00
Date of mapping	2007-03-29 10:57:00	**Plot Date**	2008-05-08 22:05:17
		Signed data	

ROCKTYPE LAXEMAR
- Fine-grained granite
- Quartz monzodiorite

ROCK STRUCTURE
- Massive

ROCK ALTERATION
- Oxidized

INTENSITY
- Weak
- Medium

ROCK TEXTURE
- Equigranular
- Unequigranular

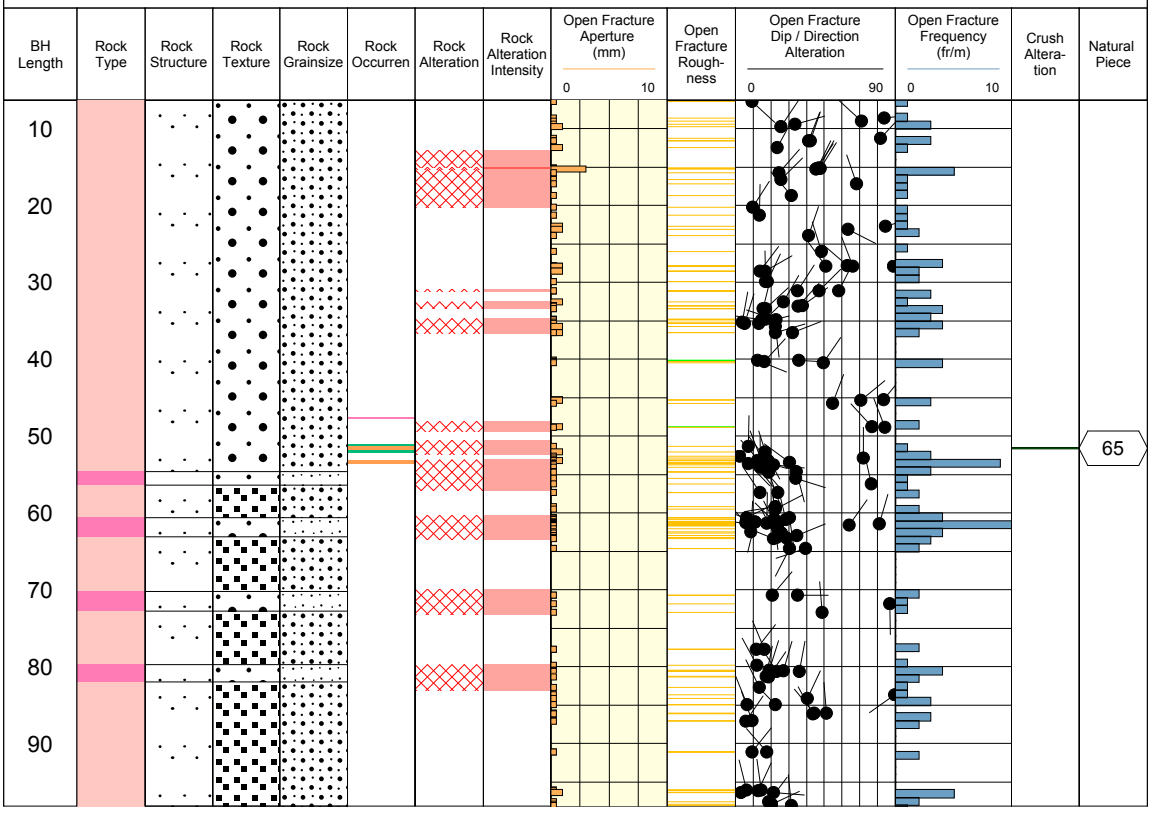
FRACTURE ALTERATION

ROUGHNESS
- Undulating
- Stepped

ROCK OCCURRENCE
- Fine-grained granite
- Pegmatite
- Fine-grained diorite-gabbro

ROCK GRAINSIZE
- Fine to medium grained
- Medium to coarse grained

SIMPLIFIED BOREMAP MAPPING



Simplified geology KLX21B

Title SIMPLIFIED GEOLOGY KLX21B **Appendix**

Site	LAXEMAR	**Coordinate System**	RT90-RHB70
Borehole	KLX21B	**Northing [m]**	6366164.00
Diameter [mm]	76	**Easting [m]**	1549715.10
Length [m]	858.780	**Elevation [m.a.s.l.]**	10.68
Bearing [°]	225.05	**Drilling Start Date**	2006-09-20 07:00:00
Inclination [°]	-70.85	**Drilling Stop Date**	2006-09-25 19:00:00
Date of mapping	2007-04-02 14:58:00	**Plot Date**	2008-05-08 22:05:17
		Signed data	

ROCKTYPE LAXEMAR
- Fine-grained granite
- Ävrö granite
- Fine-grained diorite-gabbro

ROCK STRUCTURE
- Massive

ROCK ALTERATION
- Oxidized

INTENSITY
- Weak
- Medium

ROCK TEXTURE
- Porphyritic
- Equigranular
- Unequigranular

ROUGHNESS
- Planar
- Undulating

FRACTURE ALTERATION

ROCK OCCURRENCE
- Fine-grained granite

ROCK GRAINSIZE
- Fine-grained
- Fine to medium grained
- Medium to coarse grained

SIMPLIFIED BOREMAP MAPPING