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Oskarshamn site investigation

Simplified Boremap mapping of percussion boreholes HLX13, HLX21, HLX22, HLX23, HLX24, HLX25, HLX30, HLX31 and HLX33 on lineament EW007

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Keywords: Simplified Boremap mapping.

Reading instruction

The revision no. 1 of this report: The origin of rock type fine-grained dioritoid has been partially revised in borehole HLX13 after the drilling and subsequent investigation of identical rock type in KLX20A, to dolerite /11/. See Table 5-1, as well as Chapters 5 and 6. See also WellCAD representation in Appendix 1. See also new table 1-2.

Abstract

Simplified Boremap mapping has been performed for percussion boreholes HLX13, HLX21, HLX22, HLX23, HLX24, HLX25, HLX30, HLX31 and HLX33 situated at the linked lineament EW007 in the central part of the Laxemar sub area at the site investigation Oskarshamn, Sweden.

The purpose of the activity reported here is to map 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 is Ävrö granite (over 90%) except in boreholes HLX13 and HLX25 where more mafic rock types make up part of the lithology. At first the mafic rock in HLX13 was characterized as a fine-grained dioritoid, but core borehole KLX20A cuts through identical rock and was sampled and analysed, making it clear that the mafic rock was a dolerite dike.

Alteration occurs mainly in the form of red staining (oxidation).

All boreholes cut through water yielding zones which together at the end of each borehole gave more than 100 l/min except for borehole HLX13 which gave no water.

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

Denna rapport presenterar förenklad Boremap kartering av hammarborrhål HLX13, HLX21, HLX22, HLX23, HLX24, HLX25, HLX30, HLX31 och HLX33. De borrades mot lineament EW007 i centrala delen av Laxemar området vid platsundersökningarna i 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 alla de karterade borrhålen är Ävrögranit (över 90 %) utom i hammarborrhålen HLX13 och HLX25 där mafiskare bergarter utgör en del av litologin. I början blev den mafiska bergarten i HLX13 karakteriserad som en finkornig dioritoid, men borrhål KLX20A som går igenom identisk bergart som blev provtagen och analyserad, klargjorde att den mafiska bergarten var en diabasgång.

Omvandling förekommer främst i form av rödfärgning (oxidering).

Alla borrhålen klippte vattenförande zoner som sammanlagt vid slutet av varje hål gav mer än 100 l/min förutom i borrhål HLX13 som inte gav något vatten.

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

Contents

1 Introduction

To investigate the linked, east-west trending lineament with the designation EW007 in the central part of the Laxemar sub area of the Oskarshamn site investigation, see Figure 1-1, nine percussion boreholes were drilled in 2004 /1, 2/.

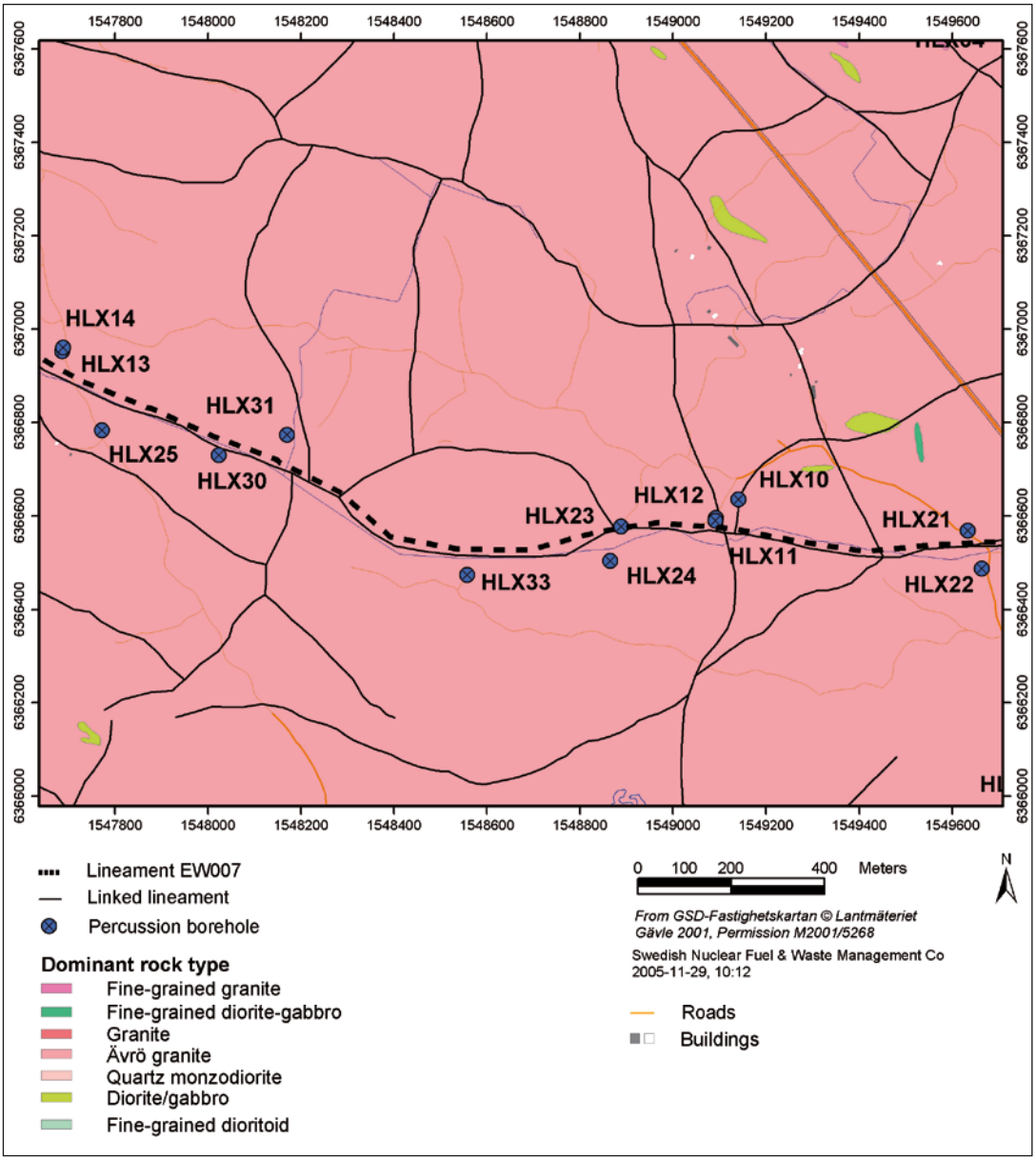

Figure 1-1. *Location of all percussion boreholes at lineament EW007 in the Laxemar sub area. The map also shows the bedrock geology, linked lineaments, roads and houses. No BIPS-image exists for boreholes HLX10, 11, 12 and 14 and they are therefore not included in this report.*

This document reports data gained by Simplified Boremap mapping of percussion boreholes HLX13, 21, 22, 23, 24, 25, 30, 31 and 33 in 2004 and 2005. The work was carried out in accordance with activity plan AP PS 400-04-124. Table 1-1 lists the controlling documents for performing this activity. Both activity plan and method description are SKB internal controlling documents.

After completing a percussion borehole it is logged with a colour TV-camera to produce images of the borehole wall called a BIPS-image (Borehole Image Processing System). Mapping of the percussion borehole is then done according to the Simplified Boremap method, in accordance with method description SKB MD 143.006 (SKB internal controlling document). It is based on the BIPS-image and makes it possible to determine the quality of the bedrock that the borehole cuts through, both petrographical (rock types, rock occurrences and alteration) and structural (open fractures, crush zones and ductile deformation). In addition the software used for the mapping (Boremap) calculates the orientation (strike and dip) of each marked planar feature.

Rock type nomenclature that has been used is shown in Table 1-2.

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

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

Activity plans	**Number**	**Version**
Förenklad Boremapkartering av HLX21 till HLX27	AP PS 400-04-124(1)	1.0
Method description	**Number**	**Version**
Metodbeskrivning för Boremap – kartering	SKB MD 143.006	1.0

(1) An amendment including the mapping of HLX13, HLX30, HLX31 and HLX33 is included in activity plan AP PS 400-04-124.

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
Quartz monzodiorite	501036	Quartz monzonite to monzodiorite, equigranular to weakly porphyritic
Diorite/gabbro	501033	Diorite to gabbro
Fine-grained dioritoid	501030	Intermediate magmatic rock
Fine-grained diorite-gabbro	505102	Mafic rock, fine-grained
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 HLX13, 21, 22, 23, 24, 25, 30, 31 and 33 in greater detail than the preliminary mapping of drill cuttings and results of measurements made while drilling the percussion hole, 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 3.7.3), which shows the BIPS-image as can be seen in Figure 3-1. Boremap is loaded with 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).

The BIPS-image quality varies; boreholes HLX13, HLX22, HLX24, HLX25, HLX30, HLX31 and HLX33 are all of relatively good quality. In all boreholes except HLX30 mud covers the lowermost parts of the borehole walls but it does not affect the visibility more than marginally. In borehole HLX23 visibility is poor at the start of the borehole because of mud in suspension. In borehole HLX21 visibility is good except for the beginning and end of borehole where mud in suspension resulted in very low to no visibility, so that the BIPS-mapping stopped before the end of the BIPS-image.

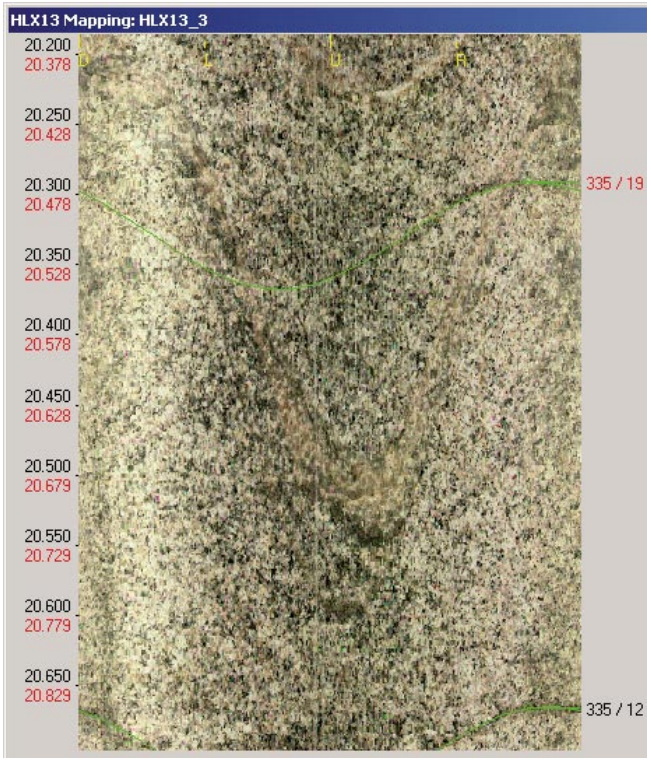

Figure 3-1. *Good quality BIPS-image as it is seen in Boremap. Borehole HLX13, showing unaltered (fresh), medium to coarse grained, massive Ävrö granite with two open fractures marked (green lines) and one thin vein consisting of fine-grained granite, unmarked.*

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 JH-8, from Geoinstruments Finland, 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,
- preliminary mapping of drill cuttings /1, 2/,
- results from percussion drilling /1, 2/,
- available geophysical measurements and interpretations /3, 4, 5, 6, 7, 8, 9/.

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.

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), in addition the BIPS-image stops at least 30 cm before the full length of the borehole because of the camera construction.

Table 4-1. Borehole data for HLX13, HLX21, HLX22, HLX23, HLX24, HLX25, HLX30, HLX31 and HLX33 (values from top of casing). Data taken from SKB database SICADA and Boremap (adjusted length).

ID-code	Northing	Easting	Bearing (degrees)	Inclination (degrees)	Diameter mm)	Borehole length (m)	End of casing (m)	BIPS-image interval, adj. length (m)
HLX13	6366953.000	1547690.420	184.181	–58.074	140	200.02	12.0	12.0–199.7
HLX21	6366568.750	1549632.363	185.541	–56.991	138	150.3	9.1	9.1–146.4
HLX22	6366487.834	1549661.542	13.451	–59.437	138	163.2	9.1	9.1–162.9
HLX23	6366578.000	2659999.600	182.893	–58.184	139	160.2	6.1	6.1–160.0
HLX24	6366503.722	1548865.890	358.692	–58,394	139	175.2	9.1	9.1–174.4
HLX25	6366783.974	1547776.324	17.935	–58.585	135	202.5	6.12	6.12–202.2
HLX30	6366730.734	1548026.729	55.816	–60.763	139	163.4	9.1	9.1–162.8
HLX31	6366774.513	1548172.268	231.772	–58.758	139	133.2	9.1	9.0–128.8
HLX33	6366471.744	1548562.705	21.769	–58.763	139	202.1	9.1	9.1–201.8

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. In this report data from Acoustic televiewer deviation measurements were used with a Moving average filter (31 points) to correct for changes in direction of boreholes with length, except for boreholes HLX30 and HLX33 where data from Magnetic-accelerometer deviation measurements were used.

4.3 Execution of measurements

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 1–5:

- 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.

4.4 Data handling

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. The bottom of HLX21 (below approximately 146.4 m adjusted length) can not be seen because of muddy water and is not mapped. The upper part of borehole HLX25 from end of casing at 6 m to 10.6 m adjusted length is above ground water level and therefore the BIPS-image is of lower quality there, which results in greater uncertainties of the Boremap mapping.

5 Results

Below the results from mapping of lithology, alteration and open fractures are given for boreholes HLX13, 21, 22, 23, 24, 25, 30, 31 and 33. The percentages of different lithologies in each borehole are given in Tables 5-1 to 5-9. The amount of alteration (red staining/ oxidation) as well as their intensity is listed in Table 5-10, while the number of open fractures and the average fracture frequency per meter can be seen in Table 5-11, and finally the crush zones mapped from the BIPS-image can be seen in Table 5-12.

HLX13

See Appendix 1 for WellCAD presentation of mapping results.

Lithology. The dominant rock type is Ävrö granite, see Figure 3-1, with lesser amount of dolerite, see Figure 5-1. The Ävrö granite contains fragments and/or enclaves of fine-grained dioritoid as well as fine-grained diorite-gabbro, all is cut by dykes and veins of fine-grained granite and pegmatite, see Table 5-1.

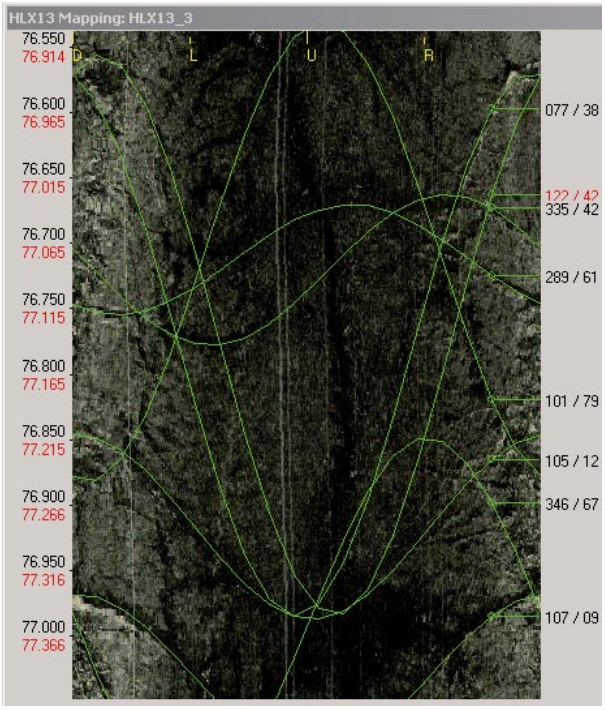

Figure 5-1. *BIPS-image as seen in Boremap of borehole HLX13 between approximately 76.9–77.4 m. Strongly fractured (green lines mark the probable open fractures), dolerite dike. No alteration can be seen.*

Table 5-1. Lithology of borehole HLX13. Percents calculated from adjusted length of BIPS-image.

Rock name	SKB rock code	%
Ävrö granite	501044	75.9
Dolerite	501027	17.4
Fine-grained dioritoid	501030	5.2
Fine-grained diorite-gabbro	505102	0.7
Fine-grained granite	511058	0.3
Pegmatite	501061	0.4

Alteration: Approximately 75% of the rock shows some alteration. Mostly weak oxidation, but medium intensity occurs also, see Table 5-10.

Open fractures: The number of mapped open fractures is 940, resulting in an average of 5.0 per meter, see Table 5-11. Highest intensity of fracture frequency is in the dolerite. One crush zone is marked at 28.98 m (adjusted length), see Table 5-12.

HLX21

See Appendix 2 for WellCAD presentation of mapping results.

Lithology: The dominant rock types are Ävrö granite cut by subordinate amounts of fine-grained granite and pegmatite, see Table 5-2 and Figure 5-2.

Table 5-2. Lithology of HLX21. Percents calculated from adjusted length of BIPS-image.

Rock name	SKB rock code	%
Ävrö granite	501044	91.9
Fine-grained granite	511058	3.9
Pegmatite	501061	4.2

Alteration: Approximately 85% of the rock shows some alteration. Mostly weak oxidation, but medium intensity occurs also, see Table 5-10.

Open fractures: A total of 694 open fractures were mapped, resulting in an average of 5.1 fractures per meter, see Table 5-11.

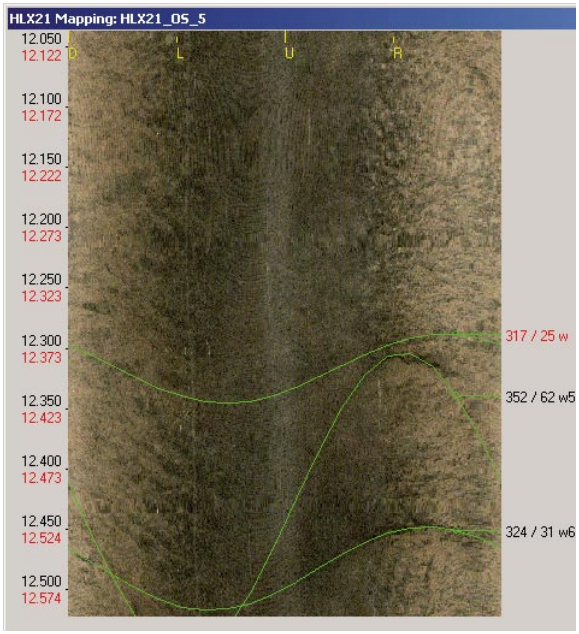

Figure 5-2. *BIPS-image as seen in Boremap, borehole HLX21, between 12.1–12.6 m (adjusted length) showing poor visibility BIPS-image with possible contact (marked red) between Ävrö granite (top of image) and pegmatite (bottom half of image) and two possible open fractures (green lines).*

HLX22

See Appendix 3 for WellCAD presentation of mapping results.

Lithology: The dominant rock type is Ävrö granite, containing fragments and/or enclaves of fine-grained diorite-gabbro, all cut by minor amounts of fine-grained granite and granite, see Table 5-3.

Table 5-3. Lithology of HLX22. Percents calculated from adjusted length of BIPS-image.

Rock name	SKB rock code	%
Ävrö granite	501044	92.1
Fine-grained granite	511058	7.0
Granite	501058	0.5
Fine-grained diorite-gabbro	505102	0.4

Alteration: Approximately 98% of the rock shows some alteration. Mainly weak oxidation, but medium intensity occurs often as well as minor strong intensity, see Table 5-10.

Open fractures: A total of 566 open fractures were mapped, resulting in an average of 3.7 fractures per meter, see Table 5-11. Four crush zones are marked here, see Table 5-12 and Figure 5-3.

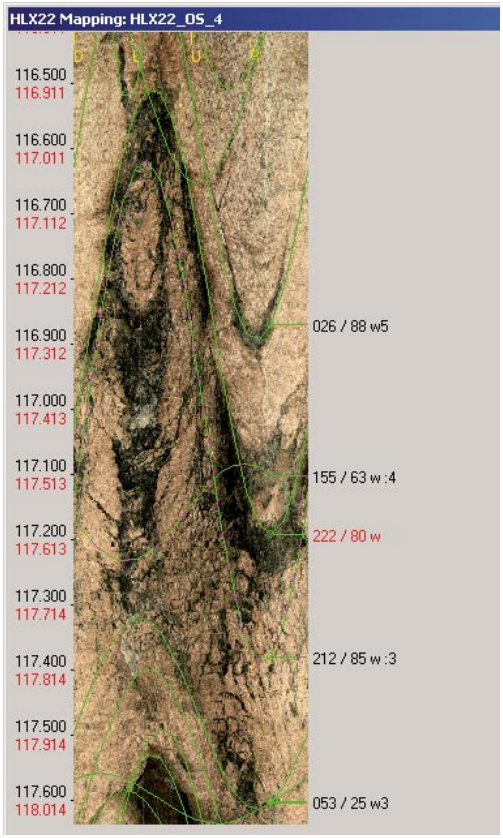

Figure 5-3. *BIPS-image as seen in Boremap, borehole HLX22 showing fine-grained granite with water yielding crush zone at 117.3 m.*

HLX23

See Appendix 4 for WellCAD presentation of mapping results.

Lithology: The dominant rock type is Ävrö granite, containing fragments and/or enclaves of fine-grained diorite-gabbro, all cut by minor amounts of fine-grained granite, see Table 5-4.

Table 5-4. Lithology of HLX23. Percents calculated from adjusted length of BIPS-image.

Rock name	SKB rock code	%
Ävrö granite	501044	92.5
Fine-grained diorite-gabbro	505102	4.8
Fine-grained granite	511058	2.7

Alteration: Approximately 78% of the rock shows some alteration. Mainly weak oxidation, but medium intensity occurs often as well as minor strong intensity, see Table 5-10.

Open fractures: A total of 368 open fractures were mapped, resulting in an average of 2.4 fractures per meter, see Table 5-11. One crush zones is marked at ca 24.7 m, see Table 5-12.

HLX24

See Appendix 5 for WellCAD presentation of mapping results.

Lithology: The dominant rock type is Ävrö granite, containing fragments and/or enclaves of fine-grained diorite-gabbro, all cut by minor amounts of fine-grained granite and pegmatite, see Table 5-5.

Table 5-5. Lithology of HLX24. Percents calculated from adjusted length of BIPS-image.

Rock name	SKB rock code	%
Ävrö granite	501044	93.0
Fine-grained diorite-gabbro	505102	6.0
Fine-grained granite	511058	0.6
Pegmatite	501061	0.4

Alteration: Approximately 97% of the rock shows some alteration. Mainly weak oxidation, but medium intensity occurs often, see Table 5-10.

Open fractures: A total of 553 open fractures were mapped, resulting in an average of 3.3 fractures per meter, see Table 5-11.

HLX25

See Appendix 6 for WellCAD presentation of mapping results.

Lithology: The dominant rock types are Ävrö granite containing fragments and/or enclaves of fine-grained diorite-gabbro. Diorite/gabbro occurs between ca 145–177 m, see Figure 5-4. Some granite and minor amounts of fine-grained dioritoid occur also. The rock types are cut by minor amounts of pegmatite and fine-grained granite, see Table 5-6.

Table 5-6. Lithology of HLX25. Percents calculated from adjusted length of BIPS-image.

Rock name	SKB rock code	%
Ävrö granite	501044	71.8
Granite	501058	5.4
Diorite/gabbro	501033	15.3
Fine-grained diorite-gabbro	505102	5.1
Pegmatite	501061	1.1
Fine-grained dioritoid	501030	0.9
Fine-grained granite	511058	0.4

Alteration: Approximately 53% of the rock shows some alteration. Mainly weak oxidation, but medium intensity occurs often, see Table 5-10.

Open fractures: A total of 471 open fractures were mapped, resulting in an average of 2.4 fractures per meter, see Table 5-11. Four crush zones are marked here, see Table 5-12.

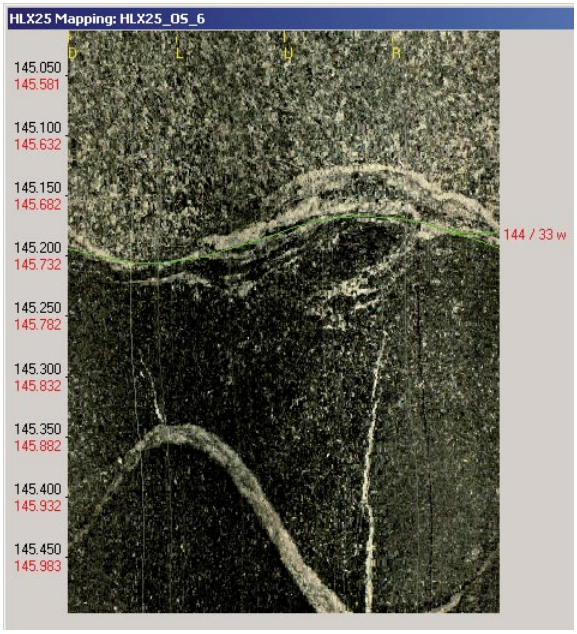

Figure 5-4. *BIPS-image as seen in Boremap, borehole HLX25 showing contact between grey, porphyritic and massive Ävrö granite and black, medium grained, massive diorite/gabbro. Veins of light grey granite occur at border and in diorite/gabbro.*

HLX30

See Appendix 7 for WellCAD presentation of mapping results.

Lithology: The dominant rock type is Ävrö granite containing fragments and/or enclaves of fine-grained diorite-gabbro all cut by minor amounts of fine-grained granite, see Table 5-7.

Table 5-7. Lithology of HLX30. Percents calculated from adjusted length of BIPS-image.

Rock name	SKB rock code	%
Ävrö granite	501044	94.6
Fine-grained diorite-gabbro	505102	5.3
Fine-grained granite	511058	0.1

Alteration: Approximately 95% of the rock shows some alteration. Mainly weak oxidation, but medium intensity occurs often, see Table 5-10.

Open fractures: A total of 1027 open fractures were mapped, resulting in an average of 6.7 fractures per meter, see Table 5-11. Three crush zones are marked here, see Table 5-12.

HLX31

See Appendix 8 for WellCAD presentation of mapping results.

Lithology: The rock type is Ävrö granite containing minor fragments and/or enclaves of fine-grained diorite-gabbro, see Table 5-8.

Table 5-8. Lithology of HLX31. Percents calculated from adjusted length of BIPS-image.

Rock name	SKB rock code	%
Ävrö granite	501044	98.9
Fine-grained diorite-gabbro	505102	1.1

Alteration: Approximately 97% of the rock shows some alteration. Mostly weak oxidation, but medium intensity occurs also, see Table 5-10.

Open fractures: A total of 357 open fractures were mapped, resulting in an average of 3.0 fractures per meter, see Table 5-11. Two crush zones are marked here, see Table 5-12.

HLX33

See Appendix 9 for WellCAD presentation of mapping results.

Lithology: The dominant rock type is Ävrö granite containing fragments and/or enclaves of fine-grained diorite-gabbro, all cut by minor amounts of fine-grained granite, see Table 5-9.

Table 5-9. Lithology of HLX33. Percents calculated from adjusted length of BIPS-image.

Rock name	SKB rock code	%
Ävrö granite	501044	95.2
Fine-grained diorite-gabbro	505102	4.6
Fine-grained granite	511058	0.2

Alteration: Approximately 90% of the rock shows some alteration. Mostly weak oxidation, but medium intensity occurs also, see Table 5-10.

Open fractures: A total of 589 open fractures were mapped, resulting in an average of 3.1 fractures per meter, see Table 5-11. One crush zone is marked at ca 22.9 m, see Table 5-12.

Table 5-10. Total alteration of percussion boreholes HLX13, HLX21, HLX22, HLX23, HLX24, HLX25, HLX30, HLX31 and HLX33.

Borehole ID	Alteration Intesity		
	Weak	Medium	Strong
HLX13	69	6	–
HLX21	56	29	–
HLX22	58	33	7
HLX23	49	26	3
HLX24	57	40	–
HLX25	32	21	–
HLX30	65	30	–
HLX31	87	10	–
HLX33	73	17	–

Table 5-11. Total number of open fractures in percussion boreholes HLX13, HLX21, HLX22, HLX23, HLX24, HLX25, HLX30, HLX31 and HLX33.

Borehole ID	Total number of open fractures	Fractures/ meter
HLX13	940	5.0
HLX21	694	5.1
HLX22	566	3.7
HLX23	368	2.4
HLX24	553	3.3
HLX25	471	2.4
HLX30	1,027	6.7
HLX31	357	3.0
HLX33	589	3.1

Table 5-12. Mapped crush zones in percussion boreholes HLX13, HLX21, HLX22, HLX23, HLX24, HLX25, HLX30, HLX31 and HLX33. Strike/dip from top of crush zone.

Borehole ID	Adjusted length (m)	Total width of zone (m)	Piece length (m)	Strike/dip (degrees)
HLX13	28.98	0.19	0.30	184/17
HLX21	–	–	–	–
HLX22	13.75	0.14	0.75	161/17
HLX22	40.83	0.04	0.15	353/16
HLX22	42.03	0.05	0.15	156/22
HLX22	117.26	0.62	0.30	222/80
HLX23	24.72	0.18	0.50	298/16
HLX24	–	–	–	–
HLX25	8.03	0.28	0.90	321/03
HLX25	50.39	0.98	0.50	096/30
HLX25	114.22	0.12	0.60	098/49
HLX25	177.23	0.53	0.50	044/37
HLX30	20.37	0.31	0.04	053/44
HLX30	61.03	0.10	0.25	156/20
HLX30	153.41	0.10	0.08	066/28
HLX31	96.76	0.14	0.10	033/20
HLX31	126.15	0.23	0.25	054/24
HLX33	22.91	0.04	0.20	103/22

6 Summary and discussions

The lithology dominating the boreholes is Ävrö granite, containing occasional fine-grained diorite-gabbro fragments and cut by minor amounts of fine-grained granite and pegmatite. Alterations, mainly in the form of red staining (oxidation) vary between boreholes.

In boreholes HLX13 and HLX25 considerable amount of mafic rock occurs. In HLX13 it is fine to medium grained, homogenous, with even and unaffected contacts and often strongly fractured, see Figure 5-1, indicating a dolerite dike as the most probable rock type. In HLX25 the mafic rock is medium grained and often with felsic veins both at the contacts and in the rock itself, see Figure 5-4, indicating a diorite/gabbro as the most probable rock type. Some of the fine-grained matic rocks contain feldspar megacrysts and are therefore interpreted as fine-grained dioritoid.

All the boreholes described here yield considerable amounts of water except for borehole HLX13, in spite of a strong increase in fracture frequency in the mafic rock (at ca 75–108 m). The water yielding zones occur both as open fractures and as fracture zones. The existence of water yielding open fracture and/or fracture zones does not proof the existence of a deformational zone, but it suggests one possible explanation of the linked lineament at the point of intersection with the boreholes.

One observation worth noting here is the distribution of alteration (red staining) in the borehole rock walls. In the eastern part it is generally more extensive and stronger in the boreholes drilled to the north (HLX22 and HLX24), while the boreholes with southerly directions generally show lower alteration (HLX21 and HLX23) at least at the end of the holes.

The Acoustic televiewer deviation measurements that were done for boreholes HLX13 /5/, HLX21–25 /6/ and HLX31 have been calculated with a Moving average filter (31 points) and used in the Boremap mapping to correct for changes in the direction of each borehole with length. For boreholes HLX30 and HLX33 deviation measurements were conducted with Magnetic accelerometer /7/.

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, but can normally not be assigned to a specific fracture. Only one alteration type of open fractures is identified in the BIPS-image i.e. red colouring of rims, but they can rarely be verified in the rock cuttings.

The only structural features measured were in borehole HLX30, a weak foliation at ca 57 m, striking 188 degrees and dipping 80 degrees to the east, roughly parallel to several proximal open fractures, and weak banding measured in Ävrö granite surrounded by fine-grained diorite-gabbro at ca 135 m striking ca 77 degrees and dipping ca 19 degrees to the south-east.

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Simplified geology HLX13

Title SIMPLIFIED GEOLOGY HLX13 **Appendix**

Site	LAXEMAR	**Coordinate System**	RT90-RHB70
Borehole	HLX13	**Northing [m]**	6366953.00
Diameter [mm]	140	**Easting [m]**	1547690.42
Length [m]	200.200	**Elevation [m.a.s.l.]**	17.39
Bearing [°]	184.18	**Drilling Start Date**	2004-02-24 12:00:00
Inclination [°]	-58.06	**Drilling Stop Date**	2004-02-26 18:50:00
Date of mapping	2004-09-13 16:49:00	**Plot Date**	2008-05-07 22:05:06
		Signed data	

ROCKTYPE LAXEMAR
- Dolerite
- Fine-grained granite
- Ävrö granite
- Fine-grained dioritoid

ROCK STRUCTURE
- Veined
- Massive

ROCK ALTERATION
- Oxidized

INTENSITY
- Weak
- Medium

FRACTURE ALTERATION

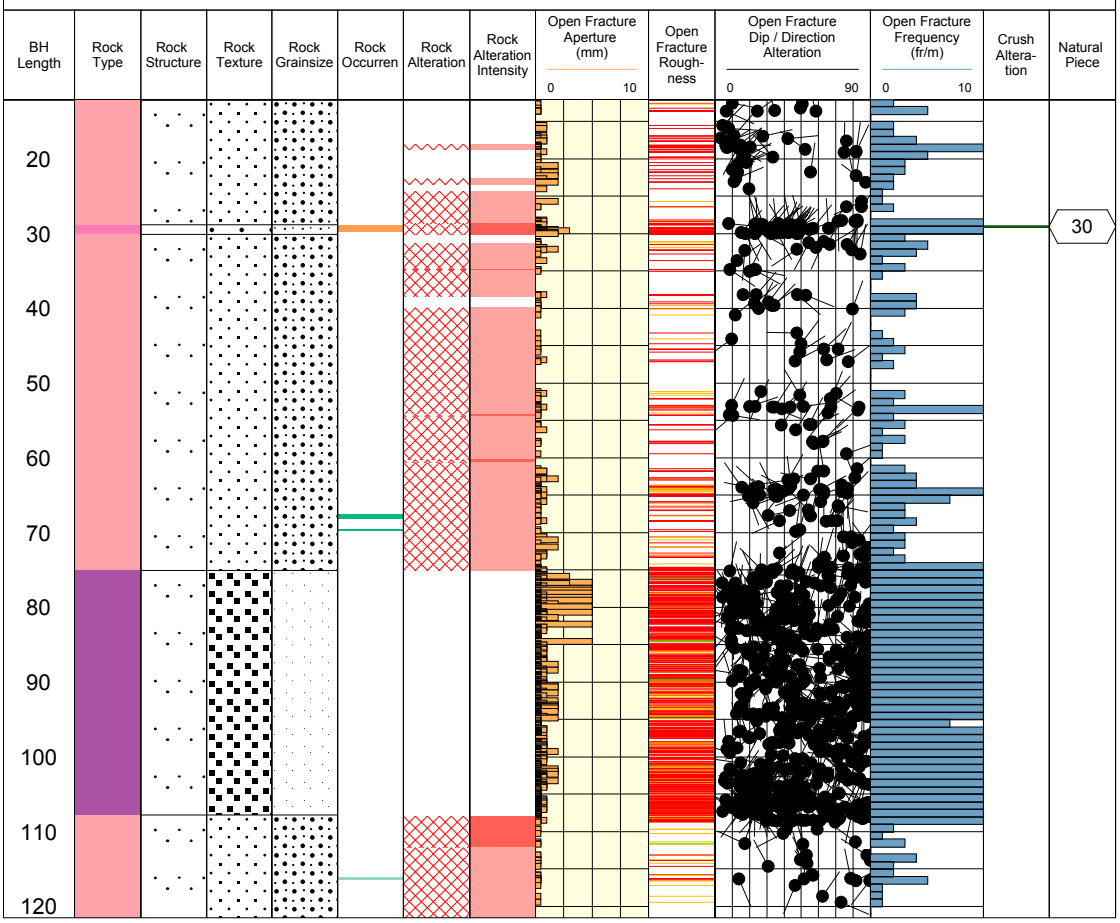
ROCK TEXTURE
- Porphyritic
- Equigranular
- Unequigranular

ROUGHNESS
- Planar
- Undulating
- Stepped

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

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

SIMPLIFIED BOREMAP MAPPING



Simplified geology HLX21

Title SIMPLIFIED GEOLOGY HLX21 **Appendix** 2

Site	LAXEMAR	**Coordinate System**	RT90-RHB70
Borehole	HLX21	**Northing [m]**	6366568.75
Diameter [mm]	138	**Easting [m]**	1549632.36
Length [m]	150.300	**Elevation [m.a.s.l.]**	10.31
Bearing [°]	185.54	**Drilling Start Date**	2004-08-30 08:00:00
Inclination [°]	-56.98	**Drilling Stop Date**	2004-09-02 09:00:00
Date of mapping	2004-10-21 16:15:00	**Plot Date**	2006-01-12 00:28:45
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ROCKTYPE LAXEMAR
- Fine-grained granite
- Pegmatite
- Ävrö granite

ROCK STRUCTURE
- Massive

ROCK ALTERATION
- Oxidized

INTENSITY
- Weak
- Medium

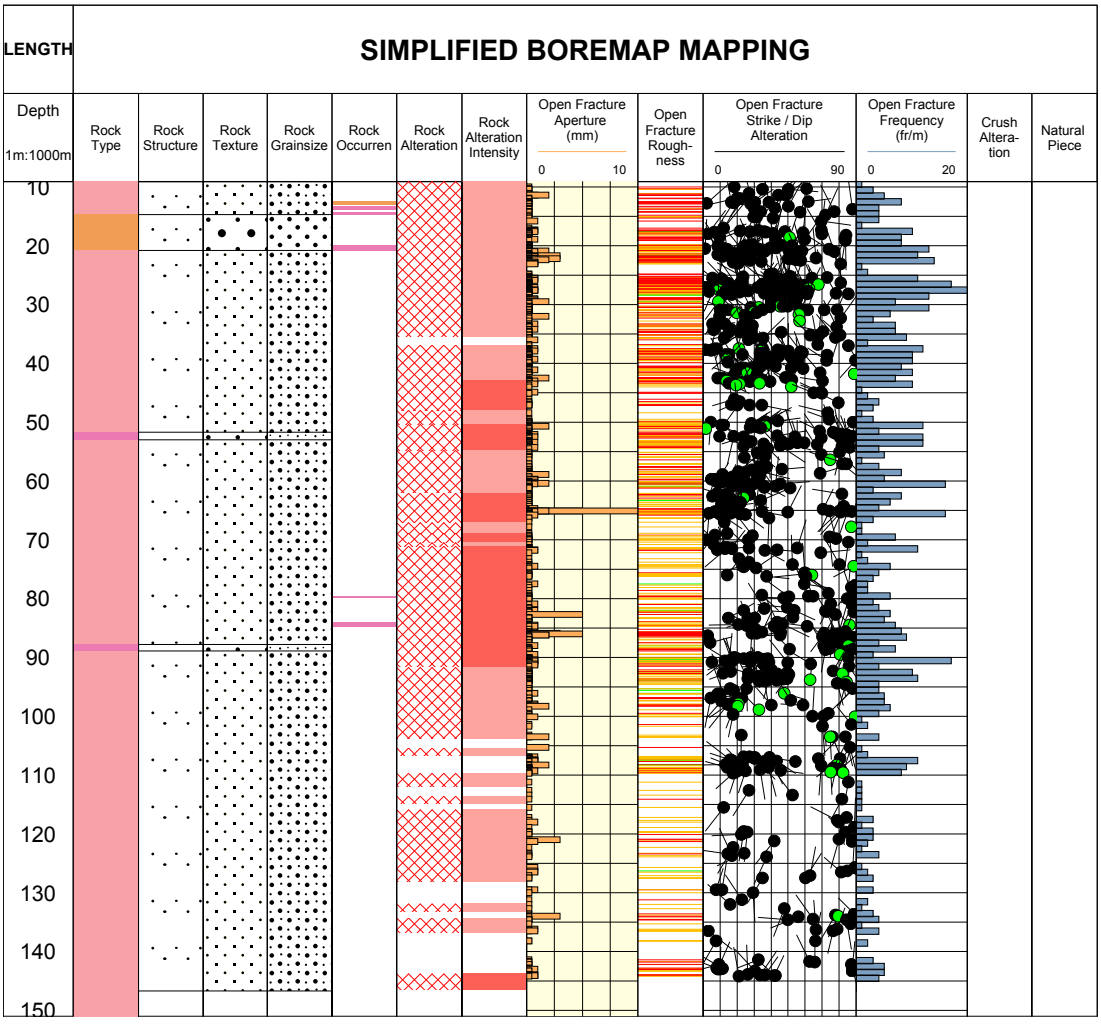
ROCK TEXTURE
- Porphyritic
- Unequigranular

ROUGHNESS
- Planar
- Undulating
- Stepped

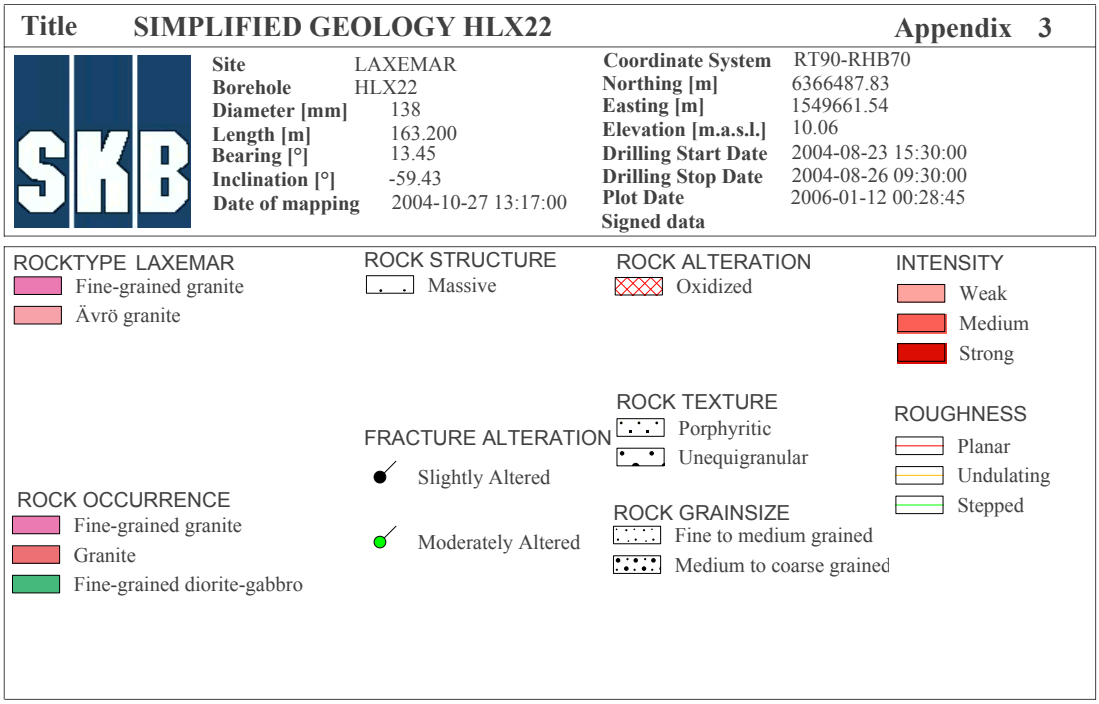
FRACTURE ALTERATION
- Slightly Altered
- Moderately Altered

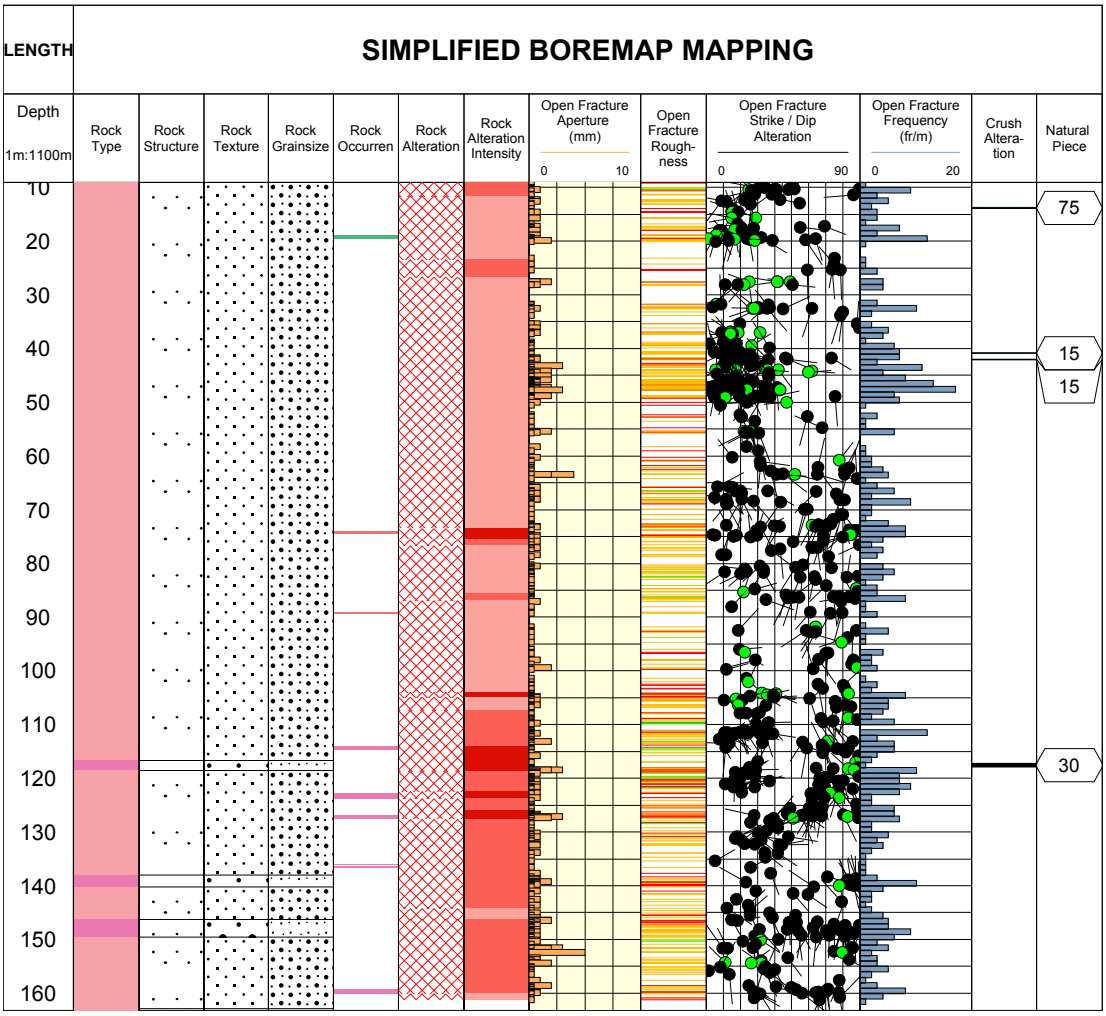
ROCK OCCURRENCE
- Fine-grained granite
- Pegmatite

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



Simplified geology HLX22





Simplified geology HLX23

Title SIMPLIFIED GEOLOGY HLX23 **Appendix** 4

Site	LAXEMAR	**Coordinate System**	RT90-RHB70
Borehole	HLX23	**Northing [m]**	6366578.01
Diameter [mm]	139	**Easting [m]**	1548888.67
Length [m]	160.200	**Elevation [m.a.s.l.]**	14.69
Bearing [°]	182.89	**Drilling Start Date**	2004-09-13 12:30:00
Inclination [°]	-58.17	**Drilling Stop Date**	2004-09-16 10:00:00
Date of mapping	2004-11-01 13:54:00	**Plot Date**	2006-01-12 00:28:45
		Signed data	

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

ROCK STRUCTURE
- Veined
- Massive

ROCK ALTERATION
- Oxidized

INTENSITY
- Weak
- Medium
- Strong

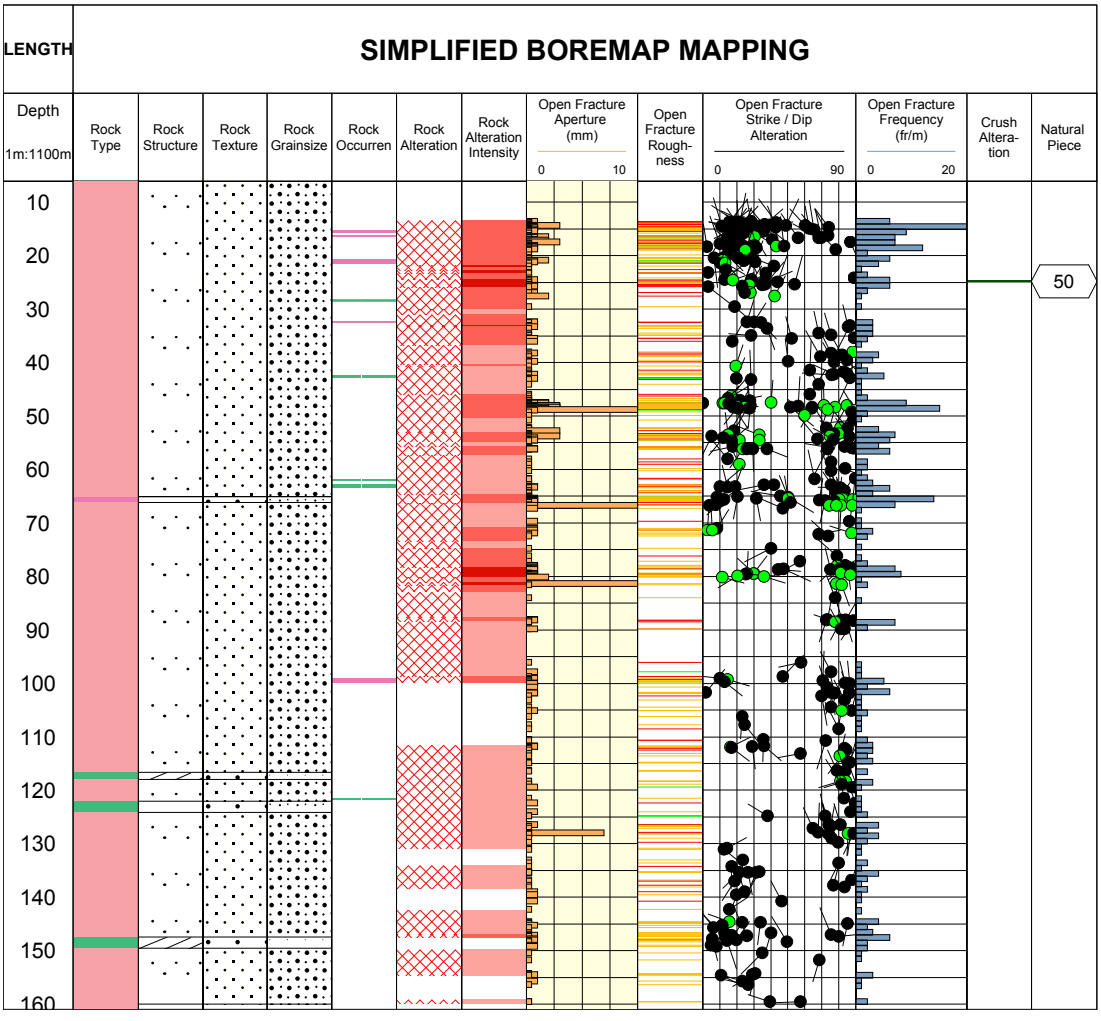
ROCK TEXTURE
- Porphyritic
- Unequigranular

ROUGHNESS
- Planar
- Undulating
- Stepped

FRACTURE ALTERATION
- Slightly Altered
- Moderately Altered

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

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



Simplified geology HLX24

Title SIMPLIFIED GEOLOGY HLX24 **Appendix 5**

Site	LAXEMAR	**Coordinate System**	RT90-RHB70
Borehole	HLX24	**Northing [m]**	6366503.72
Diameter [mm]	139	**Easting [m]**	1548865.89
Length [m]	175.200	**Elevation [m.a.s.l.]**	12.77
Bearing [°]	358.69	**Drilling Start Date**	2004-09-06 13:00:00
Inclination [°]	-58.38	**Drilling Stop Date**	2004-09-09 10:00:00
Date of mapping	2004-11-03 07:43:00	**Plot Date**	2006-01-12 00:28:45
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ROCKTYPE LAXEMAR
- Ävrö granite
- Fine-grained diorite-gabbro

ROCK STRUCTURE
- Veined
- Massive

ROCK ALTERATION
- Oxidized

INTENSITY
- Weak
- Medium

ROCK TEXTURE
- Porphyritic
- Unequigranular

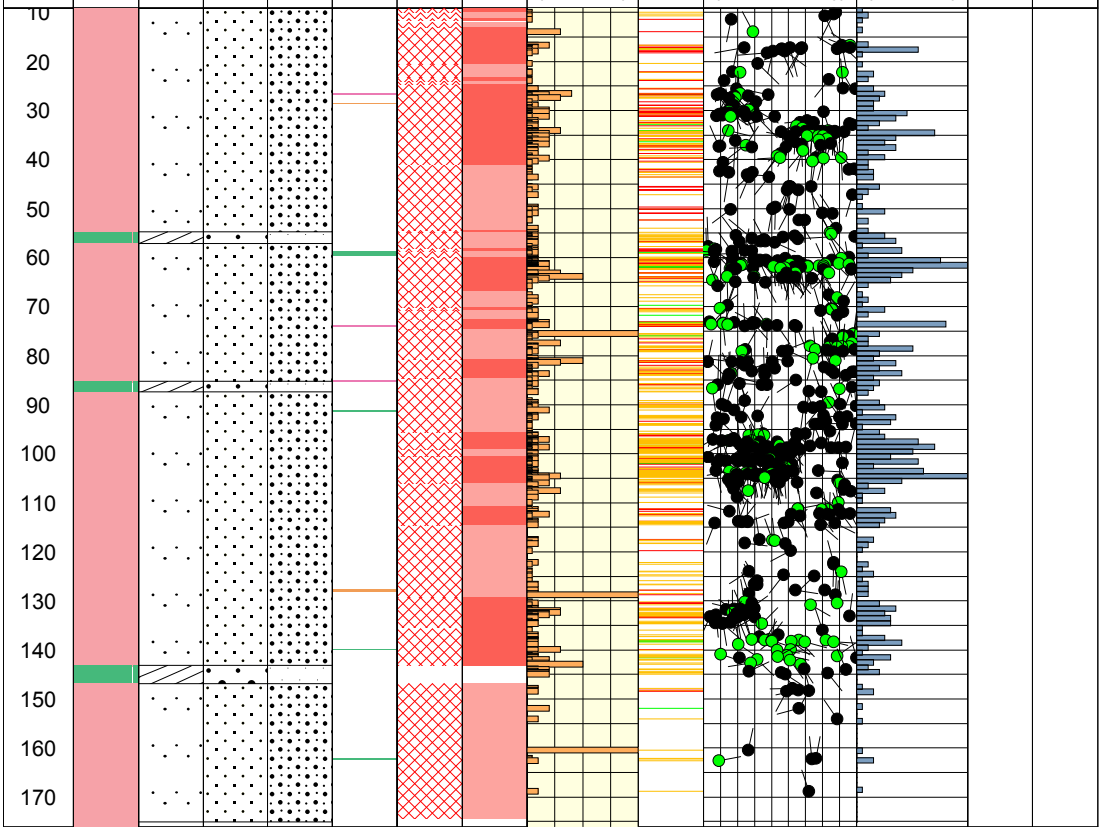
ROUGHNESS
- Planar
- Undulating
- Stepped

FRACTURE ALTERATION
- Slightly Altered
- Moderately Altered

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

ROCK GRAINSIZE
- Fine-grained
- Medium to coarse grained

SIMPLIFIED BOREMAP MAPPING



Simplified geology HLX25

Title SIMPLIFIED GEOLOGY HLX25 **Appendix** 6

Site	LAXEMAR	**Coordinate System**	RT90-RHB70
Borehole	HLX25	**Northing [m]**	6366783.97
Diameter [mm]	135	**Easting [m]**	1547776.32
Length [m]	202.500	**Elevation [m.a.s.l.]**	20.66
Bearing [°]	17.94	**Drilling Start Date**	2004-08-17 00:00:00
Inclination [°]	-58.58	**Drilling Stop Date**	2004-08-19 00:00:00
Date of mapping	2004-10-14 17:43:00	**Plot Date**	2006-01-12 00:28:45
		Signed data	

ROCKTYPE LAXEMAR
- Pegmatite
- Granite
- Ävrö granite
- Diorite / Gabbro
- Fine-grained diorite-gabbro

ROCK OCCURRENCE
- Fine-grained granite
- Pegmatite
- Granite
- Ävrö granite
- Fine-grained dioritoid
- Fine-grained diorite-gabbro

ROCK STRUCTURE
- Veined
- Massive
- Brecciated

FRACTURE ALTERATION
- Slightly Altered
- Moderately Altered
- Fresh

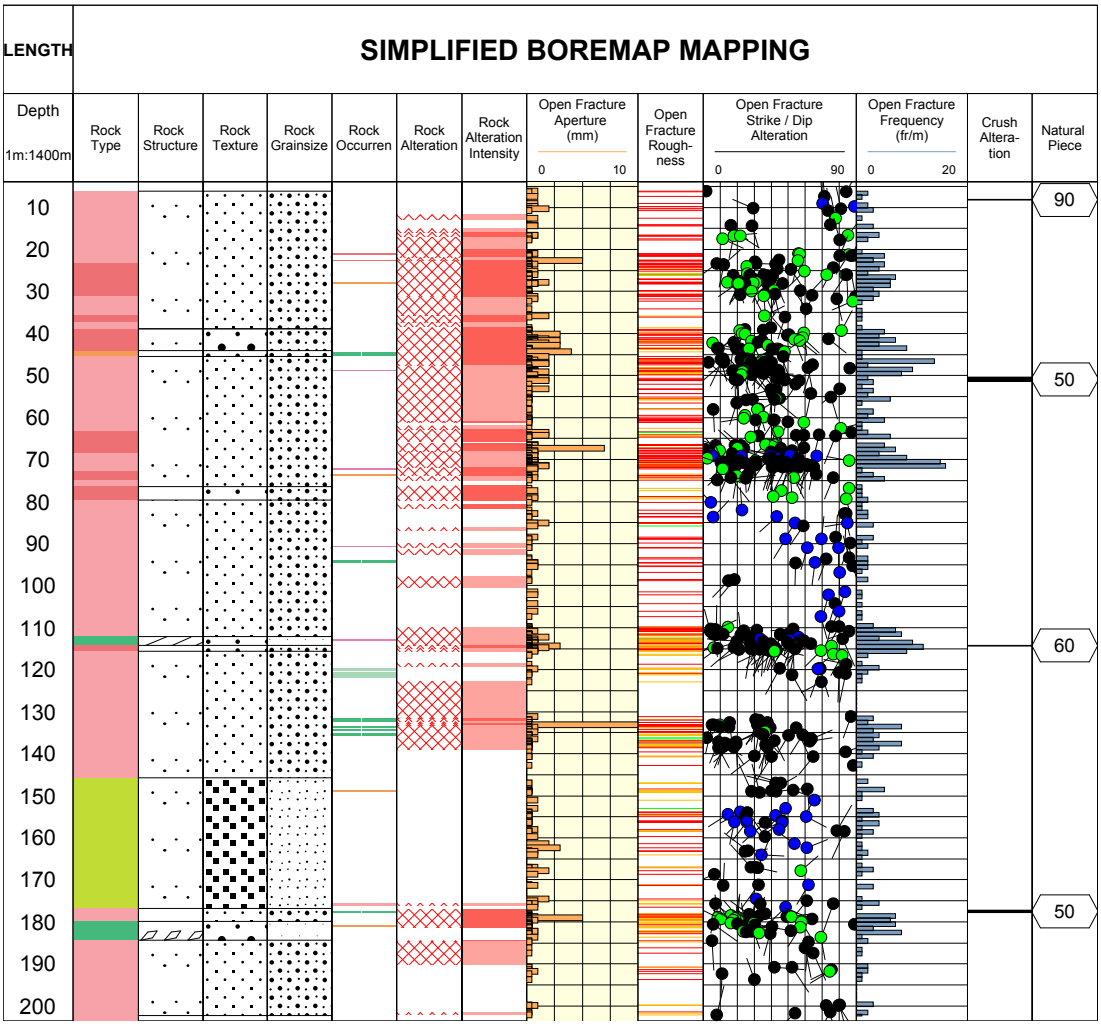
ROCK ALTERATION
- Oxidized

ROCK TEXTURE
- Porphyritic
- Equigranular
- Unequigranular

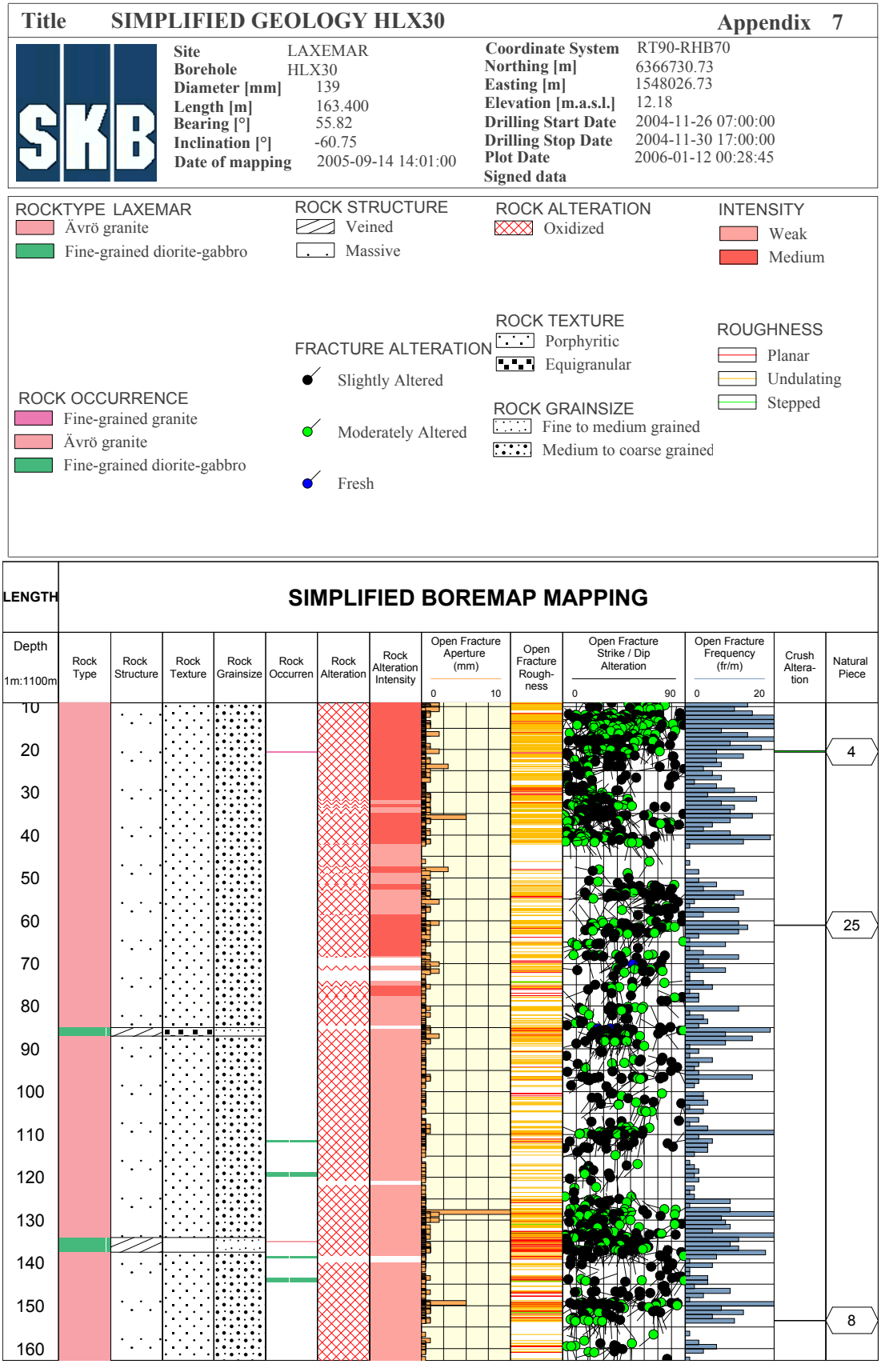
ROCK GRAINSIZE
- Fine-grained
- Fine to medium grained
- Medium to coarse grained
- Coarse-grained

INTENSITY
- Weak
- Medium

ROUGHNESS
- Planar
- Undulating
- Stepped



Simplified geology HLX30



Simplified geology HLX31

Title SIMPLIFIED GEOLOGY HLX31 **Appendix 8**

Site	LAXEMAR	**Coordinate System**	RT90-RHB70
Borehole	HLX31	**Northing [m]**	6366774.51
Diameter [mm]	139	**Easting [m]**	1548172.27
Length [m]	133.200	**Elevation [m.a.s.l.]**	12.16
Bearing [°]	231.77	**Drilling Start Date**	2004-12-01 07:00:00
Inclination [°]	-58.75	**Drilling Stop Date**	2004-12-03 12:00:00
Date of mapping	2005-12-13 15:20:00	**Plot Date**	2006-01-18 01:16:58
		Signed data	

ROCKTYPE LAXEMAR
Ävrö granite

ROCK STRUCTURE
Massive

ROCK ALTERATION
Oxidized

INTENSITY
Weak
Medium

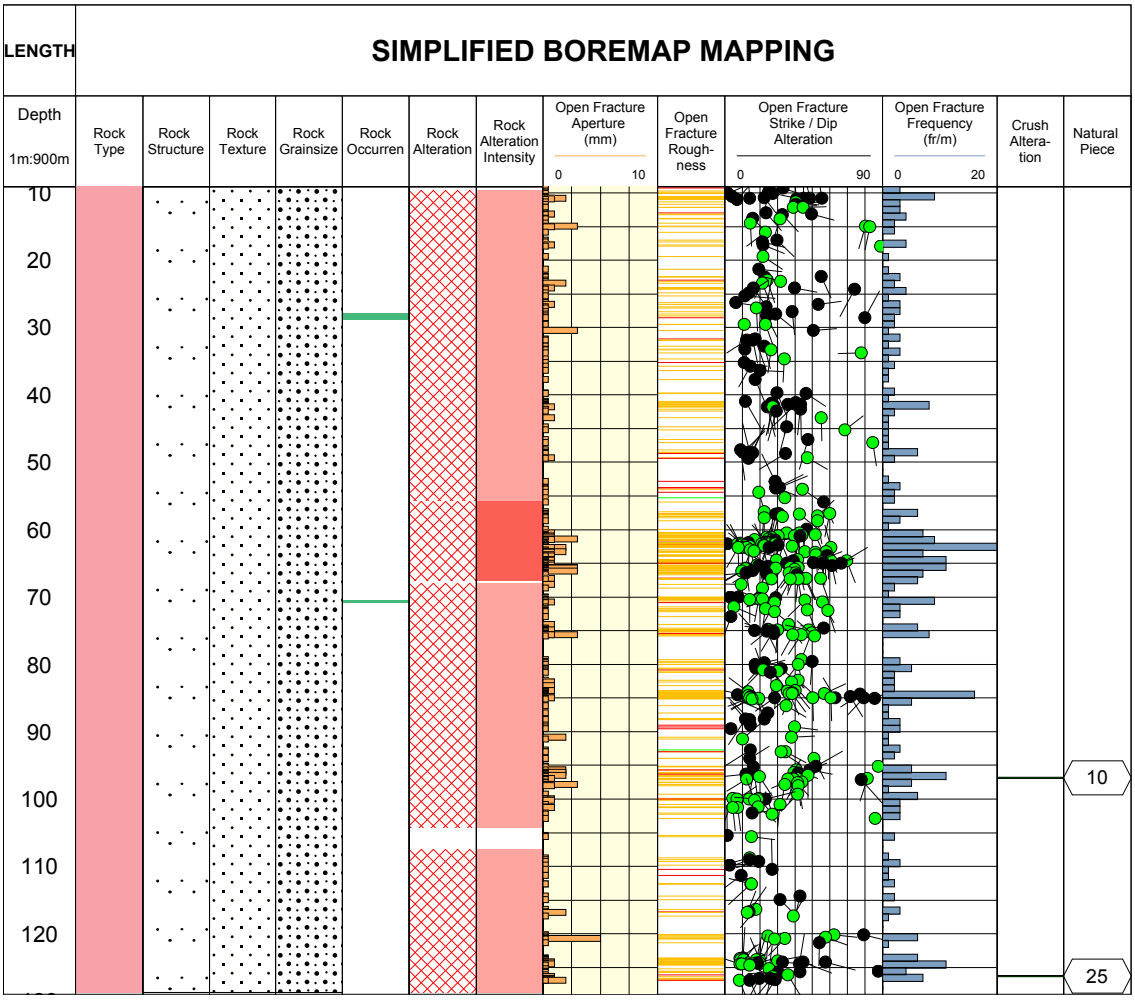
ROCK TEXTURE
Porphyritic

ROUGHNESS
Planar
Undulating
Stepped

FRACTURE ALTERATION
Slightly Altered
Moderately Altered

ROCK OCCURRENCE
Fine-grained diorite-gabbro

ROCK GRAINSIZE
Medium to coarse grained



Simplified geology HLX33

Title SIMPLIFIED GEOLOGY HLX33 **Appendix** 9

Site	LAXEMAR	**Coordinate System**	RT90-RHB70
Borehole	HLX33	**Northing [m]**	6366471.74
Diameter [mm]	139	**Easting [m]**	1548562.71
Length [m]	202.100	**Elevation [m.a.s.l.]**	12.20
Bearing [°]	21.77	**Drilling Start Date**	2004-12-17 07:00:00
Inclination [°]	-58.75	**Drilling Stop Date**	2004-12-20 19:15:00
Date of mapping	2005-10-13 14:59:00	**Plot Date**	2006-01-12 00:28:45
		Signed data	

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

ROCK STRUCTURE
- Veined
- Massive

ROCK ALTERATION
- Oxidized

INTENSITY
- Weak
- Medium

ROCK TEXTURE
- Porphyritic
- Unequigranular

FRACTURE ALTERATION
- Slightly Altered
- Moderately Altered

ROUGHNESS
- Planar
- Undulating
- Stepped

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

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