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Oskarshamn site investigation

Simplified Boremap mapping of percussion boreholes HLX38 on lineament NS059, HLX39, HLX40 and HLX41 on lineament EW900, HLX42 on lineament NE107 and HLX43 on lineament NS001

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Abstract

Simplified Boremap mapping has been performed for percussion boreholes HLX38 situated at the linked lineament NS059, boreholes HLX39, HLX40 and HLX41 situated at the linked lineament EW900, boreholes HLX42 situated at the linked lineament NE107 and borehole HLX43 situated at the linked lineament NS001, all in the western and south western part of the Laxemar subarea at the site investigation Oskarshamn, Sweden.

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 borehole HLX38 is quartz monzodiorite, cut by occasional thin dykes of fine-grained granite as well as three thin dolerite dykes. Two crush zones occur in the borehole, the lower one yielding some water below which the visibility of the BIPS-image becomes poor because of mud in suspension, increasing the importance of the rock chip drill cuttings to e.g. asses the red staining (oxidation) of the rock.

Boreholes HLX39, HLX40 and HLX41 are dominated by Ävrö granite with minor amounts of diorite-gabbro and cut by occasional fine-grained granite dykes. These boreholes are low in open fractures especially HLX40.

Borehole HLX42 is dominated by quartz monzodiorite with a few enclaves of fine-grained diorite-gabbro, mainly in the lower end of borehole, all cut by occasional thin dykes of fine-grained granite and pegmatite. Some increase of fractures in lower end of borehole.

Borehole HLX43 is dominated by Ävrö granite containing substantial amounts of diorite-gabbro enclaves, all is cut by a ca 41 m wide dolerite dyke. The Dolerite dike shows marked increase in fracture density but no water inflow.

Alteration occurs in the form of red staining (oxidation), mainly of weak intensity. The alteration in borehole HLX38 is unknown below ca 81 m because of poor visibility in BIPS-image.

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

Förenklad Boremap-kartering är utförd på hammarborrhål HLX38 på lineament NS059, hammarborrhål HLX39, HLX40 och HLX41 på lineament EW900, hammarborrhål HLX42 på lineament NE107 och hammarborrhål HLX43 på lineament NS001, alla i västra och sydvästra delen av delområde Laxemar, vid platsundersökningen Oskarshamn.

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

Den dominerande bergarten i det karterade borrhålet HLX38 är kvartsmonzodiorit, klippt av enstaka tunna gångar av finkornig granit samt tre tunna diabasgångar. Två krosszoner förekommer där den nedre är vattenförande och nedanför den är BIPS-bilden grumlig, som ökar betydelsen av kaxobservationer för t ex bedömande av bergets rödfärgning (oxidering).

Borrhålen HLX39, HLX40 och HLX41 domineras av Ävrögranit, med mindre mängder av diorit-gabbro, allt klipps av enstaka tunna gångar av finkornig granit. Dessa borrhål uppvisar låg sprickfrekvens, särskilt HLX40.

Borrhål HLX42 domineras av kvartsmonzodiorit med några enklaver av finkornig diorit-gabbro, särskilt i lägre delen av borrhålet, allt klippt av enstaka tunna gångar bestående av finkornig granit och pegmatit. Viss ökning av sprickfrekvens förekommer i lägre delen av borrhålet.

Borrhål HLX43 domineras av Ävrögranit med betydande mängder av diorit-gabbro enklaver, allt klipps av en ca 41 m bred diabasgång. Diabasgången visar tydlig förhöjning i sprickfrekvens men inget vatteninflöde.

Omvandling förekommer som rödfärgning (oxidering), för det mesta med svag intensitet. Omvandlingen i borrhål HLX38 nedanför ca 81 m är okänd på grund av grumlig BIPS-bild.

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

Contents

1 Introduction

To investigate four linked lineaments with the designation NS059 (southern part), EW900, NE107 and NS001 (northern part), all situated in the western part of the Laxemar subarea of the Oskarshamn site investigation, see Figure 1-1, six percussion boreholes were drilled in 2006 /1/.

This document reports data gained by Simplified Boremap mapping of percussion boreholes HLX38, HLX39, HLX40, HLX41, HLX42 and HLX43 in 2006 and 2007. The work was carried out in accordance with Activity plan AP PS 400-06-134. 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) /2/ and /3/. 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 document). Using the preliminary mapping of drill cuttings /1/ 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.

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

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

Activity plan	**Number**	**Version**
Förenklad Boremap-kartering av HLX38, HLX39, HLX40, HLX41, HLX42 OCH HLX43	AP PS 400-06-134	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för Boremap-kartering	SKB MD 143.006	2.0

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

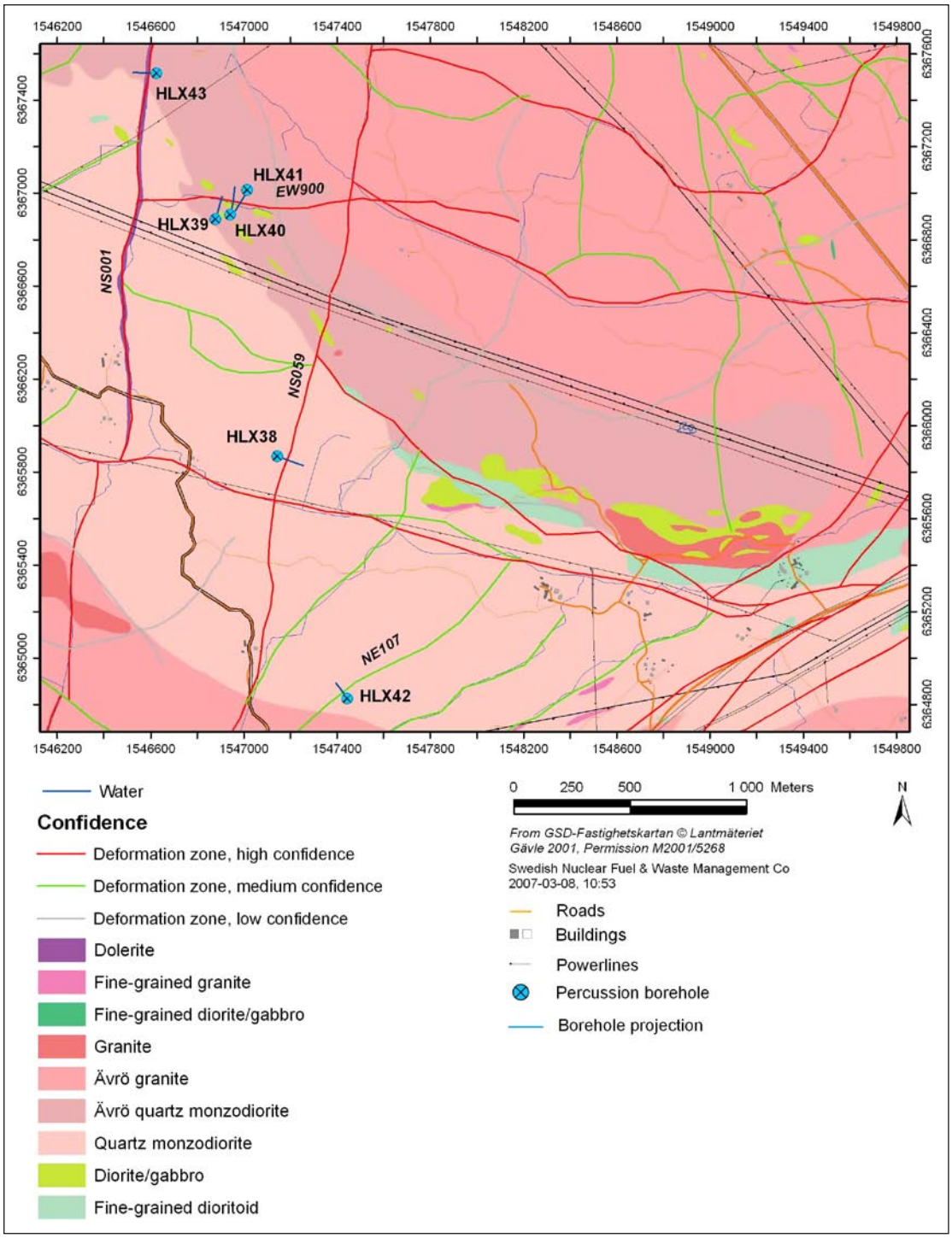


Figure 1-1. *Location of boreholes HLX38, HLX39, HLX40, HLX41, HLX42 and HLX43 in the Laxemar subarea. The map shows the bedrock geology, linked lineaments, power lines, roads and houses. The borehole HLX38 is located on the western side of the north-south trending lineament NS059 and boreholes HLX39, HLX40 and HLX41 are located on both sides of the east-west trending lineament EW900. Borehole HLX42 is located south of lineament NE107 and drilled towards the north. Finally borehole HLX43 is located on the eastern side of lineament NS001 and drilled towards the west.*

2 Objective and scope

The purpose of this survey is to map the lithology and structural parameters of percussion boreholes HLX38, HLX39, HLX40, HLX41, HLX42 and HLX43 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 3.7.3), 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 of boreholes HLX38 is medium to very poor /2/ because of mud in suspension, while in boreholes HLX39, HLX40, HLX41, HLX42 and HLX43 it is very good /3/.

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.

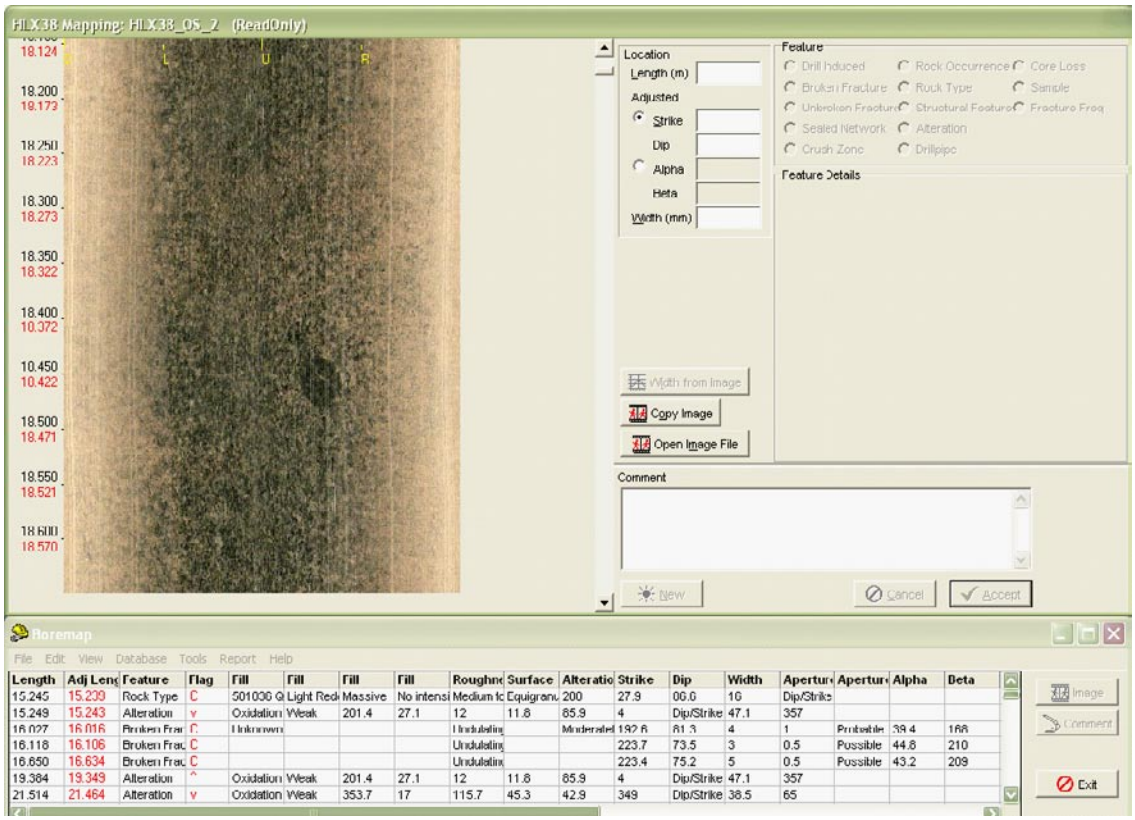


Figure 3-1. *Medium quality BIPS-image as it is seen in Boremap. Borehole HLX38, showing weakly oxidised, medium to coarse grained, massive, quartz monzodiorite, seen here with a small fragment of fine-grained diorite-gabbro. Layer of mud can be seen on bottom of borehole wall (right and left edges of image) and slight mud in suspension reduces visibility somewhat.*

4 Execution

4.1 General

Simplified Boremap mapping is comprised of data from:

- BIPS-image /2/ and /3/,
- preliminary mapping of drill cuttings /1/,
- results from percussion drilling /1/,
- available geophysical measurements and interpretations /4/ and /5/.

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, Figure 4-1, 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.

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 Magnetic accelerometer deviation measurement is used to correct for changes in direction of the boreholes with length.

Table 4-1 Borehole data for HLX38, HLX39, HLX40, HLX41, HLX42 and HLX43 (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)
HLX38	6365868.86	1547146.08	110.04	–59.39	0.140	199.50	15.10	15.24–197.42
HLX39	6366887.87	1546880.48	14.29	–59.35	0.138	199.30	6.10	5.93–198.80
HLX40	6366906.76	1546943.95	11.03	–59.57	0.138	199.50	6.10	6.07–199.06
HLX41	6367013.20	1547017.61	208.29	–59.09	0.139	199.50	6.10	5.93–199.25
HLX42	6364827.04	1547446.73	321.51	–57.11	0.139	152.60	9.10	9.10–152.60
HLX43	6367517.45	1546626.60	268.55	–50.74	0.140	170.60	6.00	6.00–170.30

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 1–4:

- 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/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 HLX38, HLX39, HLX40, HLX41, HLX42 and HLX43. 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.

HLX38

See Appendix 1 for WellCAD presentation of mapping results.

Lithology: The dominant rock type is quartz monzodiorite carrying small amounts of fine-grained diorite-gabbro, all cut by minor dykes and veins of fine-grained granite and to a lesser extent thin dolerite dykes, see Figure 5-1 and Table 5-1.

Table 5-1. Lithology of HLX38. Percents calculated from adjusted length of BIPS-image.

Rock name	SKB rock code	%
Quartz monzodiorite	501036	96.0
Fine-grained granite	511058	3.6
Fine-grained diorite-gabbro	505102	0.2
Dolerite	501027	0.2

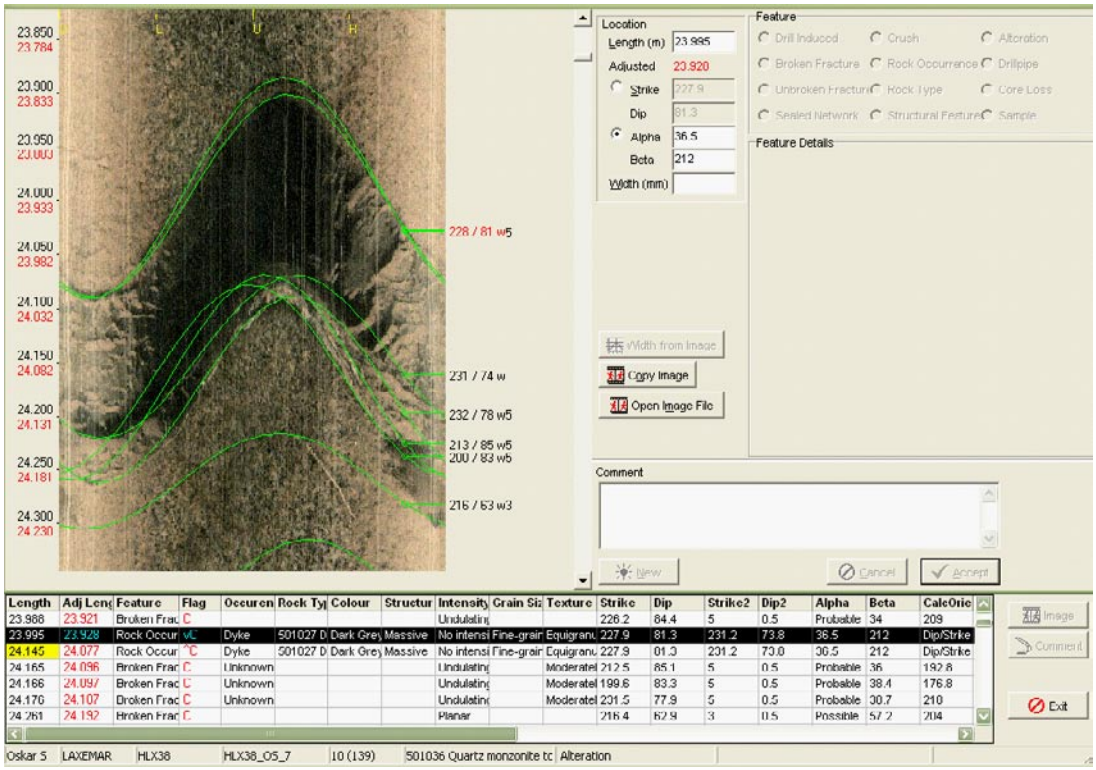


Figure 5-1. *BIPS-image as seen in Boremap, showing quartz monzodiorite in borehole HLX38 cut by fine-grained dolerite dyke. Green lines mark rock contacts as well as probable open fractures. The overall greyish-pink colouring of the borehole is a result of the precipitated clay on lower side of the borehole.*

Alteration: Alteration in the form of red staining (oxidation) occurs, in total 9%, see Table 5-7 and Appendix 1. No alteration can be mapped in HLX38 below 33.5 m because of the poor visibility in the BIPS-image, caused by mud in suspension, see Figure 5-2. The rock chip drill cuttings show that red staining (oxidation) occurs below 33.5 m, in total approximately 21%, making the total alteration of borehole HLX38 ca 30%. Below ca 104 m very little red staining occurs in the rock according to the rock chip drill cuttings.

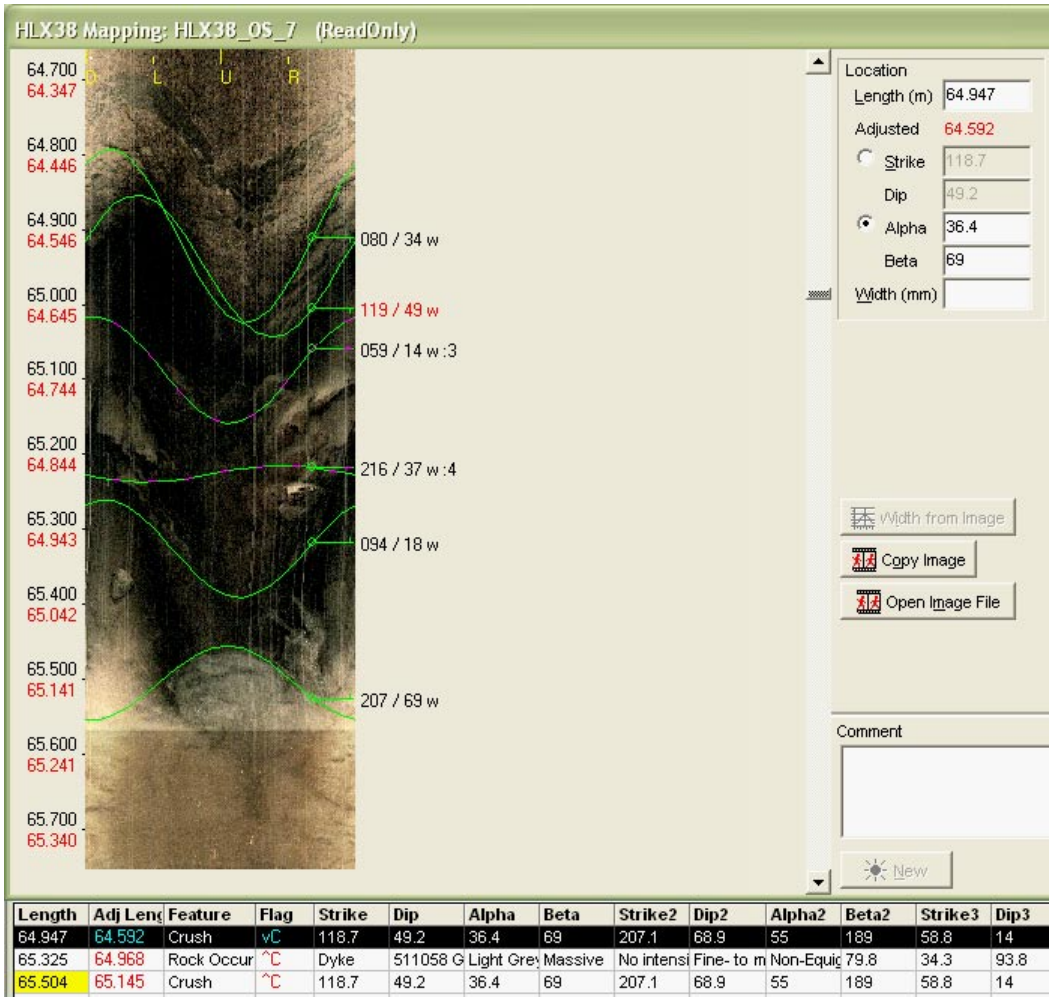


Figure 5-2. *BIPS-image as seen in Boremap, showing crush zone at ca 64.6–65.1 m (adj. length) in borehole HLX38. Mud in suspension impairs visibility at lower end, making the width uncertain. Deep cavities in the crush zone increases uncertainty of rock type. Green lines mark rock contacts as well as probable open fractures.*

Open fractures: Mapped open fractures are 96, resulting in an average of 0.52 per meter, see Table 5-8. Mud in suspension below 65 m in the borehole reduces visibility seriously which lowers the total number of visible open fractures below that depth, see Figure 5-3. Two crush zones are marked, the upper one at ca 31 m, with a possible but uncertain water inflow and the lower one at ca 64.6 m, with water inflow, but uncertain width because of mud in suspension at its lower end, making visibility very poor, see Figure 5-2 and Table 5-9.

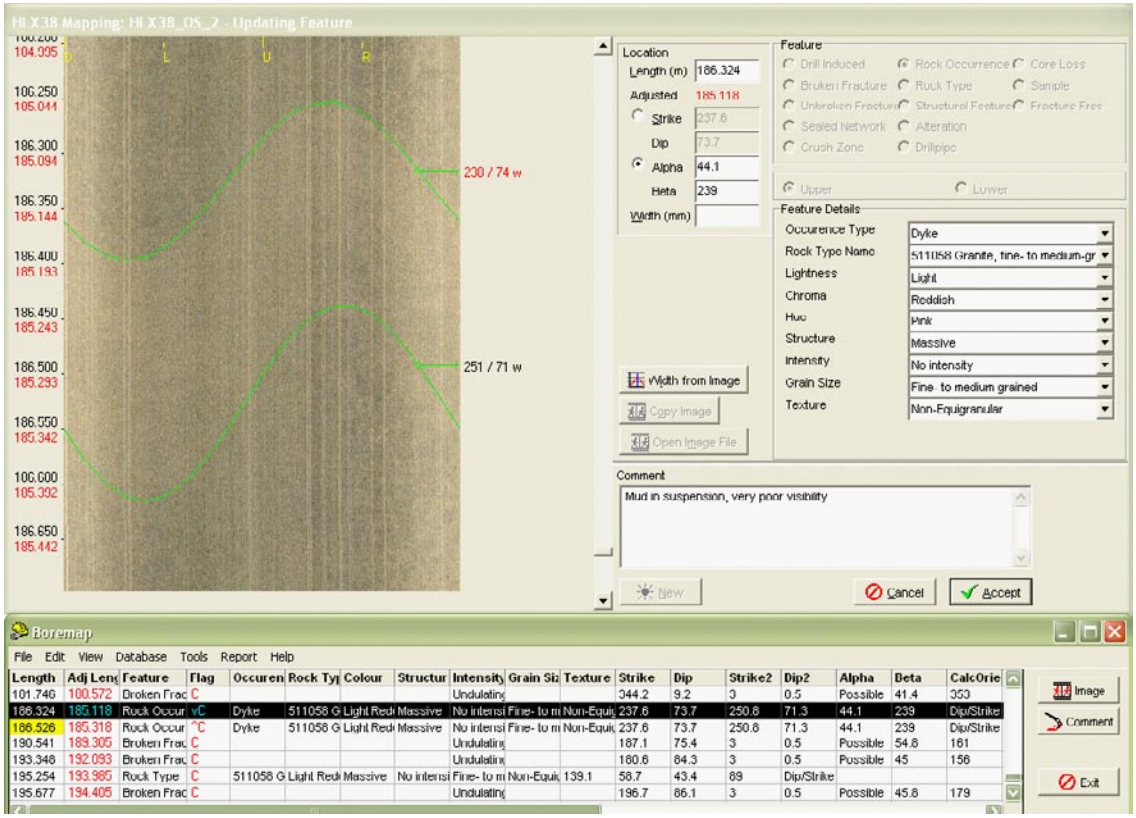


Figure 5-3. *BIPS-image as seen in Boremap, showing fine-grained granite dyke cutting the quartz monzodiorite in borehole HLX38. Mud in suspension reduces visibility seriously. Green lines mark rock contacts.*

HLX39

See Appendix 2 for WellCAD presentation of mapping results.

Lithology: The dominant rock type is Ävrö granite carrying minor amounts of diorite/gabbro, see Figure 5-4, as well as some fine-grained diorite-gabbro, all cut by dykes and veins of fine-grained granite and to a lesser extent pegmatite, see Table 5-2.

Alteration: Alteration in the form of red staining (oxidation) occurs often, in total 50%, see Table 5-7. The highest intensity (medium) is at ca 77–83 m, ca 171–174 m and ca 190–191 m, see Appendix 2. Open fractures and some water inflow somewhere at ca 191–196 m.

Open fractures: Mapped open fractures are 170, resulting in an average of 0.88 per meter, see Table 5-8. Two crush zones are marked, the upper one at ca 14.8 m and the lower one at ca 76.9 m, see Table 5-9.

Table 5-2. Lithology of HLX39. Percents calculated from adjusted length of BIPS-image.

Rock name	SKB rock code	%
Ävrö granite	501044	87.3
Diorite/gabbro	501033	7.1
Fine-grained granite	511058	3.9
Fine-grained diorite-gabbro	505102	1.4
Pegmatite	501061	0.3

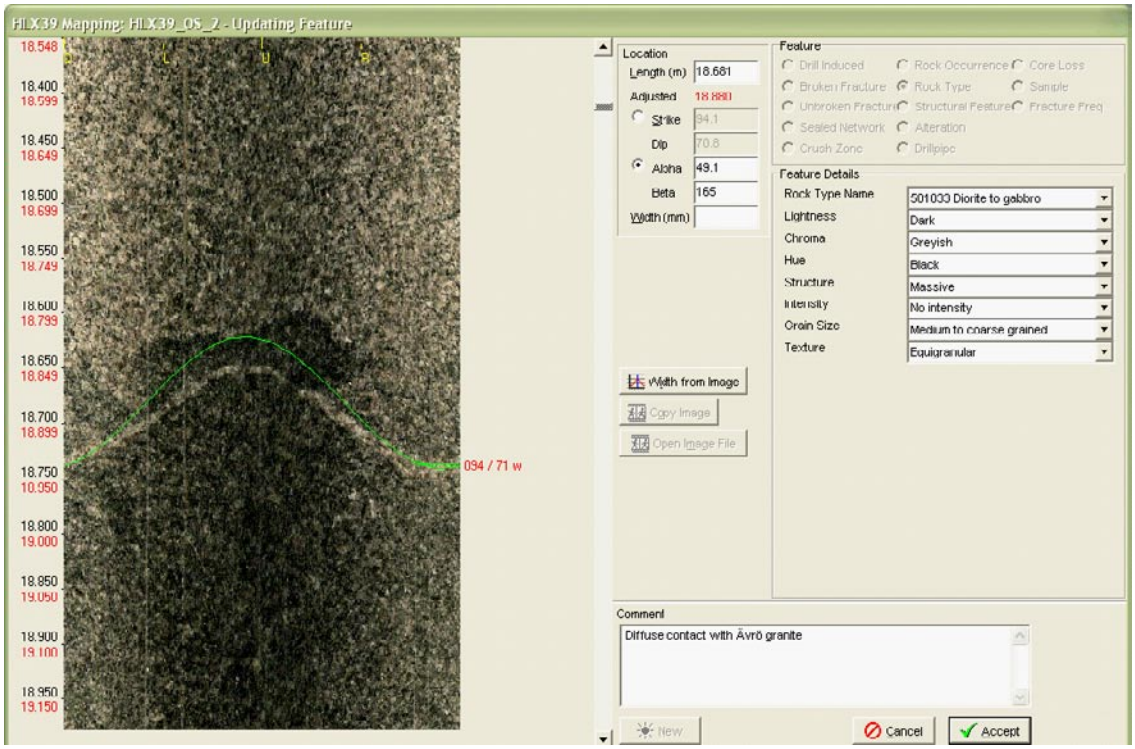


Figure 5-4. *BIPS-image as seen in Boremap, showing contact between Ävrö granite and diorite/gabbro at ca 18.88 m (adj. length) in borehole HLX39, marked with a green line.*

HLX40

See Appendix 3 for WellCAD presentation of mapping results.

Lithology: The dominant rock type is Ävrö granite carrying minor amounts of diorite/gabbro as well as some fine-grained diorite-gabbro, all cut by dykes and veins of fine-grained granite and to a lesser extent pegmatite, see Figure 5-5 and Table 5-3.

Alteration: Alteration in the form of red staining (oxidation) occurs often, in total ca 53%, see Table 5-7. The highest intensity (medium) is at ca 43–56 m, see Appendix 3.

Open fractures: Mapped open fractures are 50, resulting in an average of 0.26 per meter, see Table 5-8. One crush zone is marked, at ca 196.5 m, see Table 5-9.

Table 5-3. Lithology of HLX40. Percents calculated from adjusted length of BIPS-image.

Rock name	SKB rock code	%
Ävrö granite	501044	96.0
Diorite/gabbro	501033	1.9
Fine-grained granite	511058	1.2
Pegmatite	501061	0.6
Fine-grained diorite-gabbro	505102	0.3

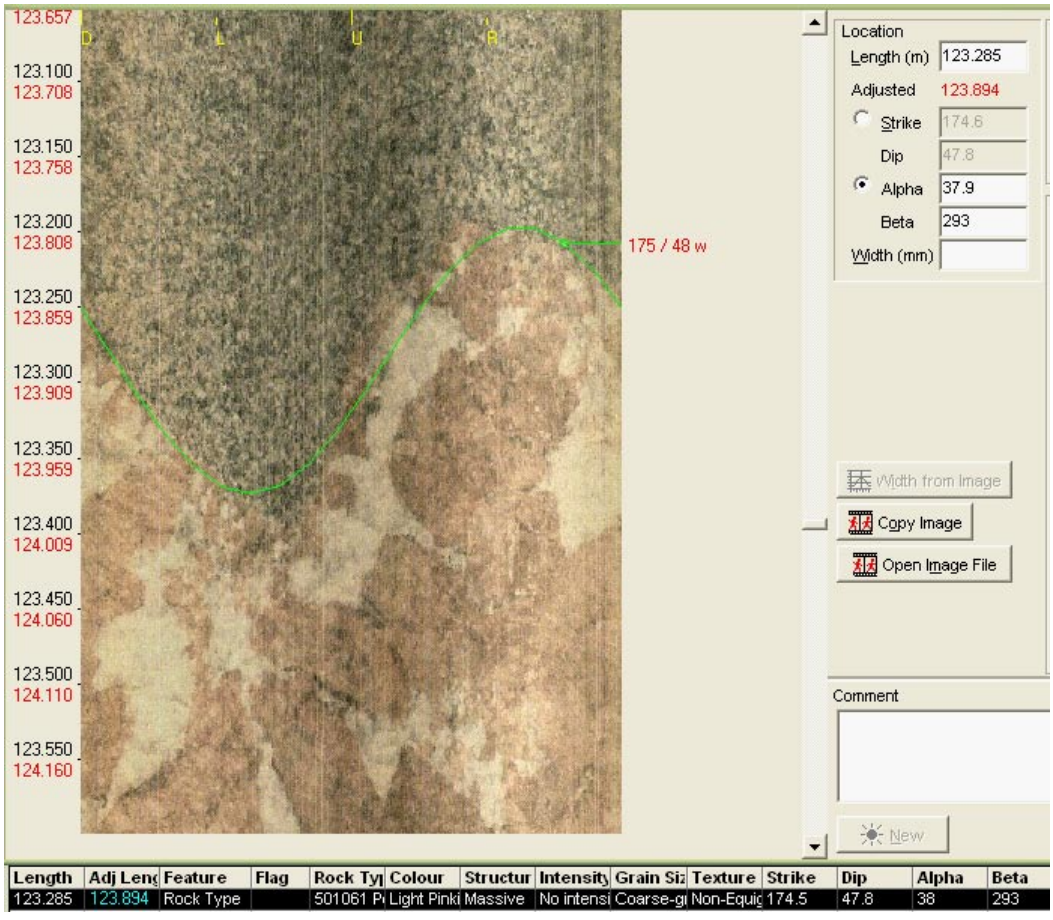


Figure 5-5. BIPS-image as seen in Boremap, showing contact between Ävrö granite and pegmatite at ca 123.89 m (adj. length) in borehole HLX40, marked with a green line.

HLX41

See Appendix 4 for WellCAD presentation of mapping results.

Lithology: The dominant rock type is Ävrö granite carrying minor amounts of diorite/gabbro as well as some fine-grained diorite-gabbro, all cut by dykes and veins of fine-grained granite and to a lesser extent pegmatite, see Table 5-4.

Alteration: Alteration in the form of red staining (oxidation) occurs often, in total ca 69%, see Figure 5-6 and Table 5-7 as well as Appendix 4.

Open fractures: Mapped open fractures are 224, resulting in an average of 4.16 per meter, see Table 5-8. Three crush zones are marked, at ca 95.8 m, 98.4 m and 121.1 m, see Figure 5-6 and Table 5-9.

Table 5-4. Lithology of HLX41. Percents calculated from adjusted length of BIPS-image.

Rock name	SKB rock code	%
Ävrö granite	501044	85.4
Fine-grained granite	511058	11.3
Diorite/gabbro	501033	2.8
Pegmatite	501061	0.3
Fine-grained diorite-gabbro	505102	0.2

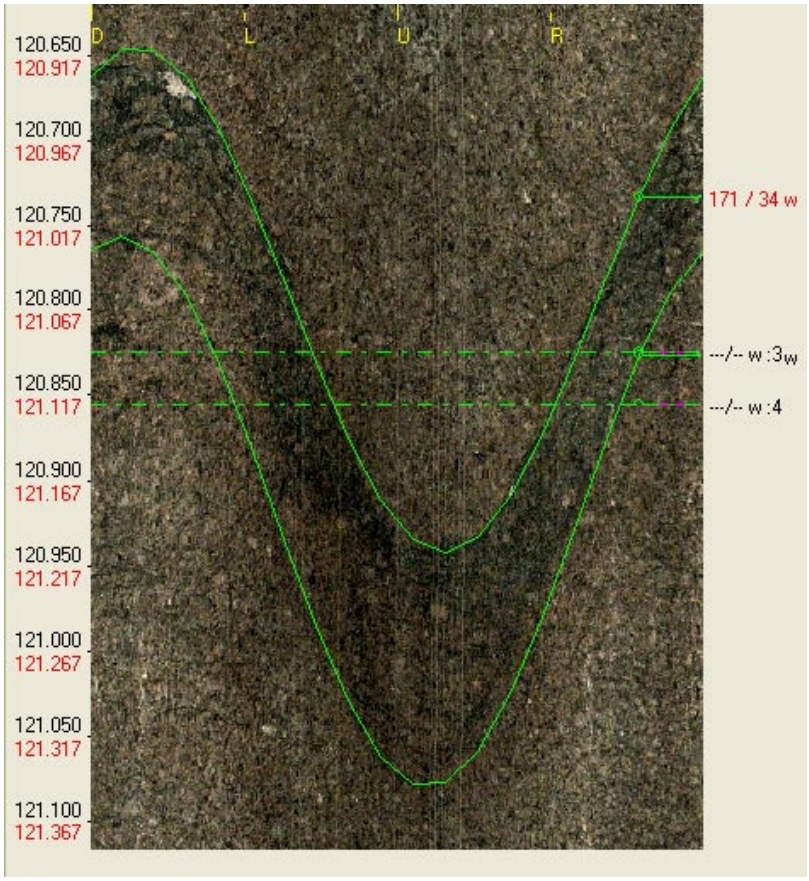


Figure 5-6. *BIPS-image as seen in Boremap, showing ca 13 cm wide crush zone at ca 121.06 m (adj. length) in borehole HLX41. Green lines mark the upper and lower end of the crush zone, but it is too narrow to interpret two main fracture directions leaving the horizontal dashed lines with no value. The rock type is Ävrö granite showing some alteration. No water inflow was noted.*

HLX42

See Appendix 5 for WellCAD presentation of mapping results.

Lithology: The dominant rock type is quartz monzodiorite carrying minor amounts of fine grained diorite-gabbro, cut by dykes and veins of fine-grained granite and to a lesser extent pegmatite, see Table 5-5 and Figure 5-7.

Alteration: Alteration in the form of red staining (oxidation) occurs often, in total ca 56.4%, see Table 5-7 and Appendix 5.

Open fractures: Mapped open fractures are 337, resulting in an average of 2.35 per meter, see Table 5-8. No crush zones were observed in the BIPS-image.

Table 5-5. Lithology of HLX42. Percents calculated from adjusted length of BIPS-image.

Rock name	SKB rock code	%
Quartz monzodiorite	501036	81.2
Fine-grained diorite-gabbro	505102	8.9
Fine-grained granite	511058	7.5
Pegmatite	501061	2.4

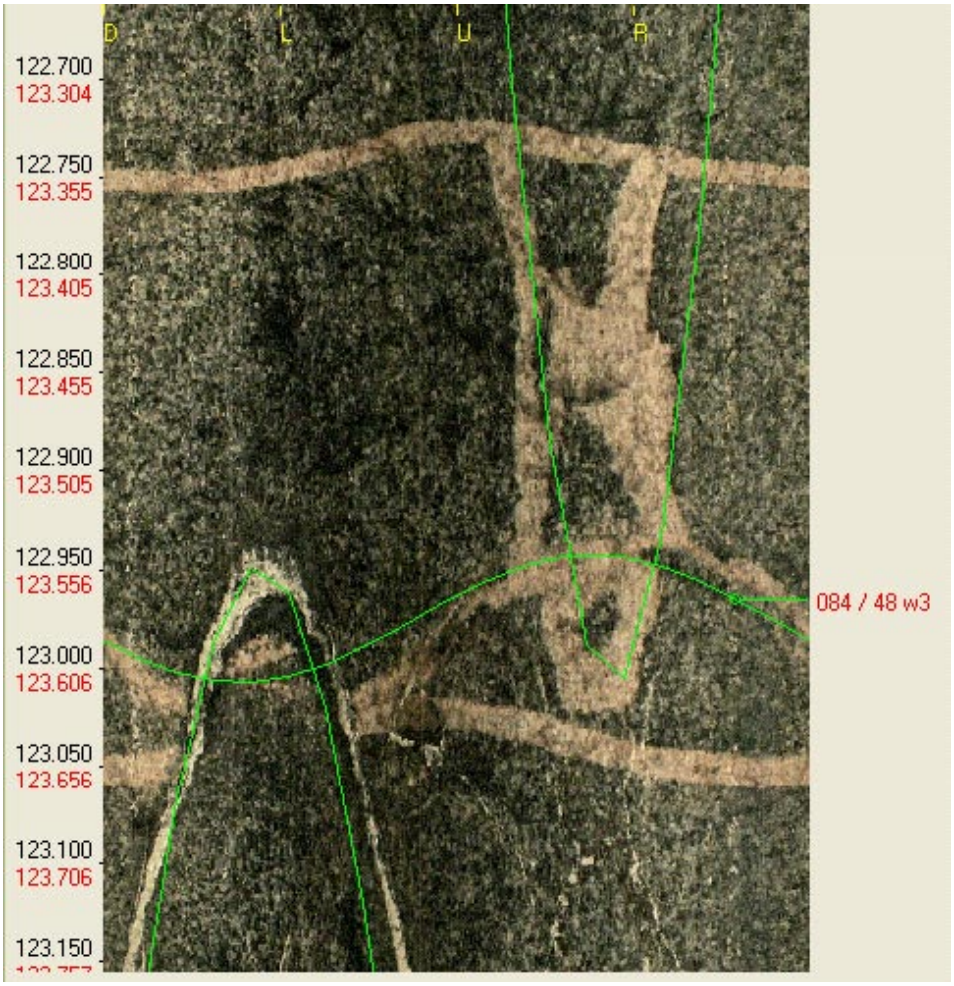


Figure 5-7. *BIPS-image as seen in Boremap, showing weakly altered quartz monzodiorite cut by thin fine-grained granite veins in borehole HLX42 at ca 123.3–123.7 m (adj. length). Green lines mark probable open fractures, the lower most with unknown filling and the other upper most showing oxidized walls. Some faulting has taken place.*

HLX43

See Appendix 6 for WellCAD presentation of mapping results.

Lithology: The dominant rock type is Ävrö granite carrying minor amounts of diorite/gabbro, all cut by dykes and veins of fine-grained granite and to a lesser extent pegmatite. A relatively homogenous and often strongly fractured dolerite dyke is a substantial rock type in borehole HLX43, see Table 5-6 and Figure 5-8.

Table 5-6. Lithology of HLX43. Percents calculated from adjusted length of BIPS-image.

Rock name	SKB rock code	%
Ävrö granite	501044	53.5
Dolerite	501027	25.1
Diorite/gabbro	501033	15.5
Fine-grained granite	511058	4.2
Pegmatite	501061	1.7

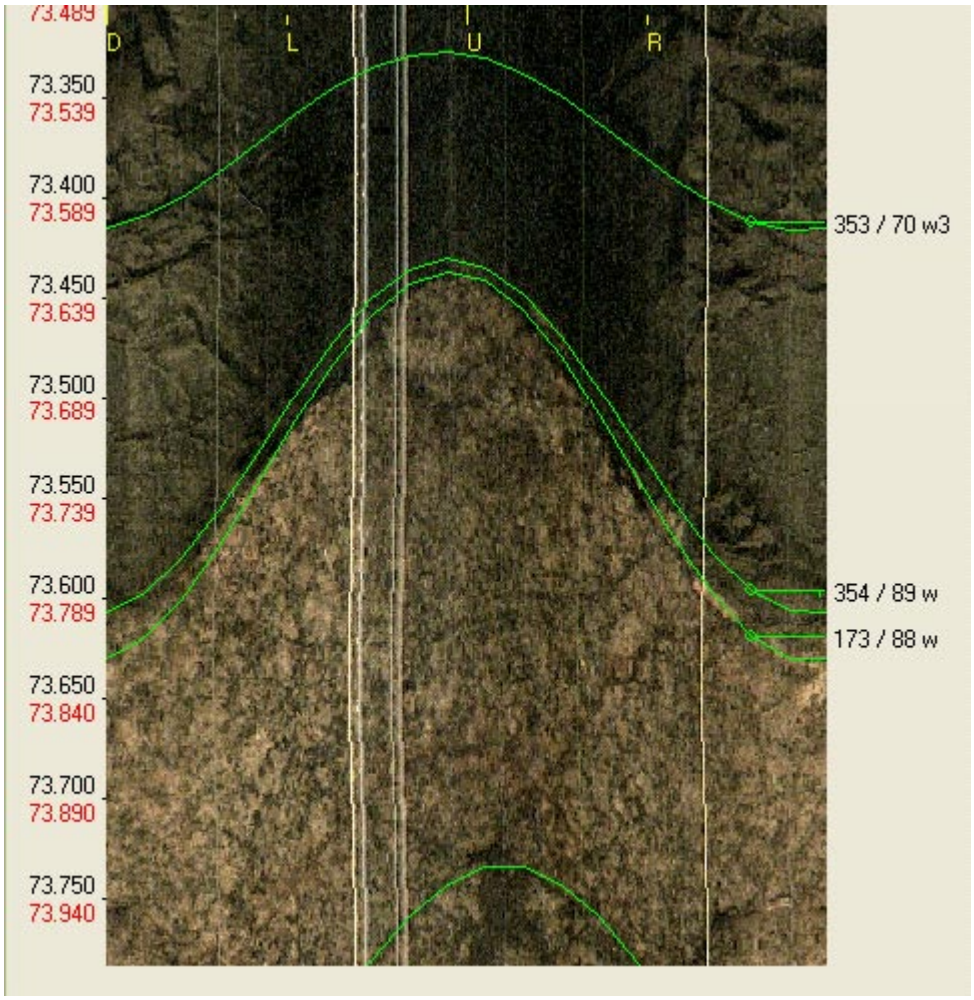


Figure 5-8. *BIPS-image as seen in Boremap, showing lower contact between dolerite dyke and Ävrö granite in borehole HLX43, at ca 73.7 m (adj. length). Green lines mark rock contact and closest to that top of weak alteration, below and above the green lines indicate probable open fractures.*

Alteration: Alteration in the form of red staining (oxidation) occurs often, in total ca 45.6%, see Table 5-7 and Appendix 5.

Open fractures: Mapped open fractures are 422, resulting in an average of 2.55 per meter, see Table 5-8. Four crush zones are marked, at ca 33.74 m, 54.00 m, 77.91 m and 80.78 m, see Table 5-9 and Figure 5-9.

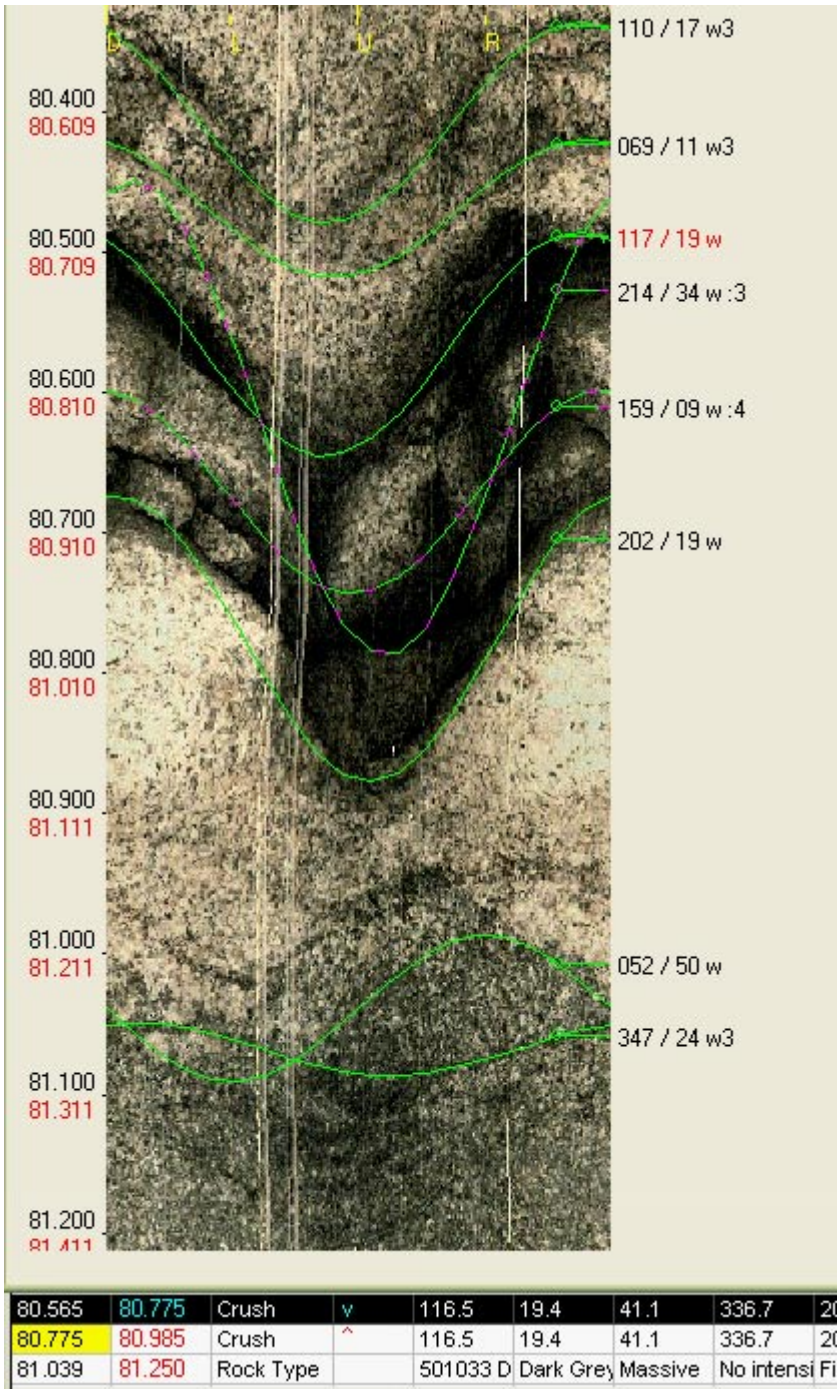


Figure 5-9. *Good quality BIPS-image as seen in Boremap from borehole HLX43, showing a water yielding crush zone at 80.78 m (adj. length) in unaltered quartz monzodiorite, contact with diorite-gabbro is at 81.25 m (adj. length) just below the crush zone. Green lines mark rock contact, crush zone with two main fracture directions and probable open fractures.*

Table 5-7. Total alteration in percussion boreholes HLX38, HLX39, HLX40, HLX41, HLX42 and HLX43.

Alteration	Intensity	HLX38 (%)	HLX39 (%)	HLX40 (%)	HLX41 (%)	HLX42 (%)	HLX43 (%)
Oxidation	**Weak**	9	45	38	64	48	44
	Medium	–	5	15	5	8	1

Table 5-8. Total number of open fractures in percussion boreholes HLX38, HLX39, HLX40, HLX41, HLX42 and HLX43.

Borehole ID	Total number of open fractures	Fractures/meter
HLX38	96	0.5
HLX39	170	0.9
HLX40	50	0.3
HLX41	224	1.2
HLX42	337	2.3
HLX43	422	2.5

Table 5-9. Mapped crush zones in percussion boreholes HLX38, HLX39, HLX40, HLX41, HLX42 and HLX43. Strike/Dip from top of crush zone.

Borehole ID	Adjusted length (m)	Total width of zone (m)	Piece length (m)	Strike/Dip (degrees)
HLX38	30.98	0.27	0.06	137/26
HLX38	64.59	0.55	0.02	119/49
HLX39	14.75	0.20	0.03	050/15
HLX39	76.86	0.25	0.04	084/28
HLX40	196.52	0.39	0.03	071/18
HLX41	95.77	0.04	0.01	192/14
HLX41	98.43	0.18	0.01	206/26
HLX41	121.06	0.13	0.01	171/34
HLX42	–	–	–	–
HLX43	33.74	0.21	0.02	350/86
HLX43	54.00	0.36	0.05	201/85
HLX43	77.91	0.23	0.03	066/27
HLX43	80.78	0.21	0.03	117/19

6 Summary and discussions

The boreholes in this report divide into four sets, borehole HLX38 drilled to test the southern part of lineament NS059, boreholes HLX39, HLX40 and HLX41 drilled to test the lineament EW900, borehole HLX42 drilled to test the lineament NE107 and finally borehole HLX43 drilled to test the northern part of lineament NS001.

The lithology dominating HLX38 is quartz monzodiorite, with minor amounts of fine-grained granite, see Table 5-1. Three thin (< 0.2 m) dolerite dykes occur between ca 24–26 m, mapped because of their age and origin, see Figure 5-1. One crush zone occurs at ca 64.6 m borehole length, see Table 5-9 and Figure 5-2, with moderate inflow of water /1/. The existence of water yielding open fracture zone does not proof the existence of a deformational zone, but it suggests one possible explanation for the linked lineament at the point of intersection with the borehole. Below ca 65 m the BIPS-image is of relatively poor quality precluding visual assessment of alteration in the form of red staining (oxidation). From the rock chip drill cuttings some red staining (oxidation) can be observed down to ca 104 m borehole length, but below that there occurs very little red staining in the rock.

The lithology dominating HLX39, HLX40 and HLX41 is Ävrö granite, with minor occurrences of diorite-gabbro and fine-grained granite, see Tables 5-2, 5-3 and 5-4. Increases in fracture frequencies occur in all three boreholes, which coincide with crush zones in boreholes HLX39 and HLX41, see Table 5-9 and Figure 5-6. Low inflow of water occurs in boreholes HLX39 and HLX40 at uncertain depths, while HLX41 showed no measurable water inflow /1/. Alterations in the form of red staining (oxidation) of mainly weak intensity occur in all three boreholes. Medium intensity red staining coincides with increase in fracture frequency in boreholes HLX39 and HLX40 at approximately 80 and 50 m borehole lengths respectively, see Appendix 2 and 3. Stronger alteration in connection with increased fracture frequency is a possible indication of a linked lineament intersecting with the borehole.

The lithology dominating HLX42 is quartz monzodiorite, with minor fine-grained diorite-gabbro and some fine-grained granite, see Table 5-5. Some increase in fracture frequency occurs at lower end of borehole, but without any distinct measurable inflow of water /1/. Alteration in the form of red staining (oxidation) of mainly weak intensity increases somewhat in the lower end of the borehole, see Appendix 5.

The lithology dominating HLX43 is Ävrö granite cut by a fine to medium grained, homogenous, often strongly fractured dolerite dike with even and unaffected contacts, see Figure 5-8. Borehole HLX43 also contains considerable amounts of diorite/gabbro both above and below the dolerite dike, see Table 5-6. Two distinct and water yielding crush zones occur at ca 78 and 81 m borehole length, see Table 5-9 and Figure 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. the talc and serpentine in the dolerite dike of borehole HLX43, 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.

References

/1/ **Ask H, 2007.** Oskarshamn site investigation. Percussion drilling of boreholes HLX38, HLX39, HLX40, HLX41, HLX42 and HLX43 for lineament investigation. SKB P-06-291, Svensk Kärnbränslehantering AB.

/2/ **Gustafsson J, Gustafsson C, 2006.** Oskarshamn site investigation. RAMAC, BIPS and deviation logging in boreholes KLX11B, KLX11C, KLX11D, KLX11E, KLX11F, KLX18A, KLX20A, HLX38 and HLX40 and BIPS and deviation logging in KLX19A. SKB P-06-159, Svensk Kärnbränslehantering AB.

/3/ **Gustafsson J, Gustafsson C, 2006.** Oskarshamn site investigation. RAMAC, BIPS and deviation logging in boreholes KLX13A, KLX14A, KLX22A, KLX22B, KLX23A, KLX23B, KLX24A, KLX25A, KLX26A, KLX26B, HLX39 and HLX41. SKB P-06-260, Svensk Kärnbränslehantering AB.

/4/ **Nielsen U T, Ringgaard J, 2006.** Oskarshamn site investigation. Geophysical borehole logging in boreholes KLX20A, KLX18A, KLX11B, KLX09B, KLX09D, KLX09F, HLX38, HLX39, HLX40 and HLX41. SKB P-06-290, Svensk Kärnbränslehantering AB.

/5/ **Mattsson H, Keisu M, 2006.** Oskarshamn site investigation. Interpretation of geophysical borehole measurements form KLX18A, KLX20A, KLX09B, KLX09D, KLX09F, KLX11B, HLX38, HLX39, HLX40, HLX41 and interpretation of petrophysical data from KLX20A. SKB P-06-292, Svensk Kärnbränslehantering AB.

Simplified geology HLX38

Title SIMPLIFIED GEOLOGY HLX38 **Appendix**

Site	LAXEMAR	**Coordinate System**	RT90-RHB70
Borehole	HLX38	**Northing [m]**	6365868.86
Diameter [mm]	139	**Easting [m]**	1547146.08
Length [m]	199.500	**Elevation [m.a.s.l.]**	11.53
Bearing [°]	110.04	**Drilling Start Date**	2006-04-10 07:00:00
Inclination [°]	-59.45	**Drilling Stop Date**	2006-04-24 16:00:00
Date of mapping	2006-05-22 17:06:00	**Plot Date**	2008-05-07 22:05:06
		Signed data	

ROCKTYPE LAXEMAR
- Fine-grained granite
- Quartz monzodiorite

ROCK STRUCTURE
- Massive

ROCK ALTERATION
- Oxidized

INTENSITY
- Weak

FRACTURE ALTERATION

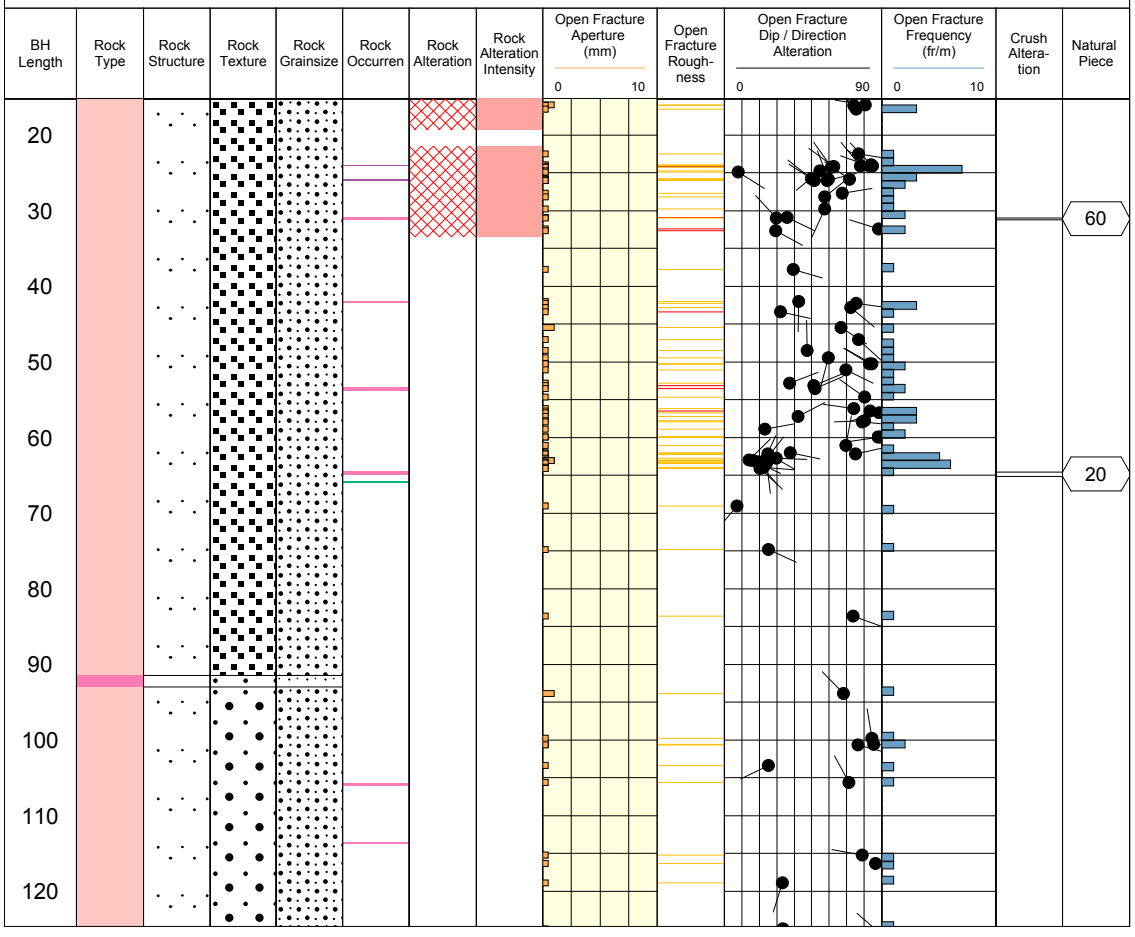
ROCK TEXTURE
- Equigranular
- Unequigranular

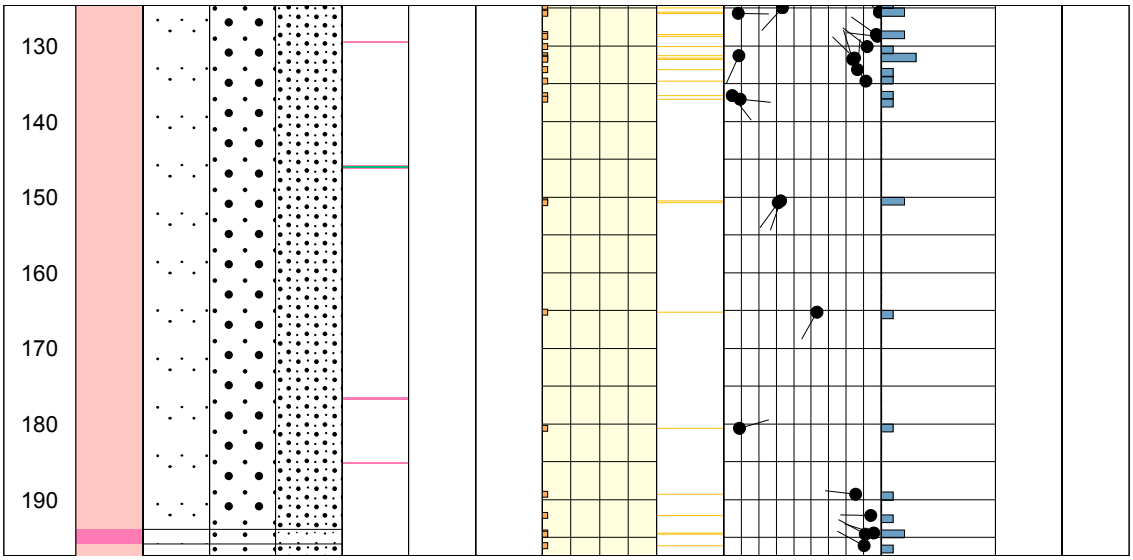
ROUGHNESS
- Planar
- Undulating

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

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

SIMPLIFIED BOREMAP MAPPING

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Simplified geology HLX39

Title SIMPLIFIED GEOLOGY HLX39 **Appendix**

Site	LAXEMAR	**Coordinate System**	RT90-RHB70
Borehole	HLX39	**Northing [m]**	6366887.87
Diameter [mm]	138	**Easting [m]**	1546880.48
Length [m]	199.300	**Elevation [m.a.s.l.]**	27.04
Bearing [°]	14.29	**Drilling Start Date**	2006-06-07 11:40:00
Inclination [°]	-59.34	**Drilling Stop Date**	2006-06-14 12:00:00
Date of mapping	2006-10-03 11:20:00	**Plot Date**	2008-05-07 22:05:06
		Signed data	

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

ROCK STRUCTURE
- Veined
- Massive

ROCK ALTERATION
- Oxidized

INTENSITY
- Weak
- Medium

FRACTURE ALTERATION

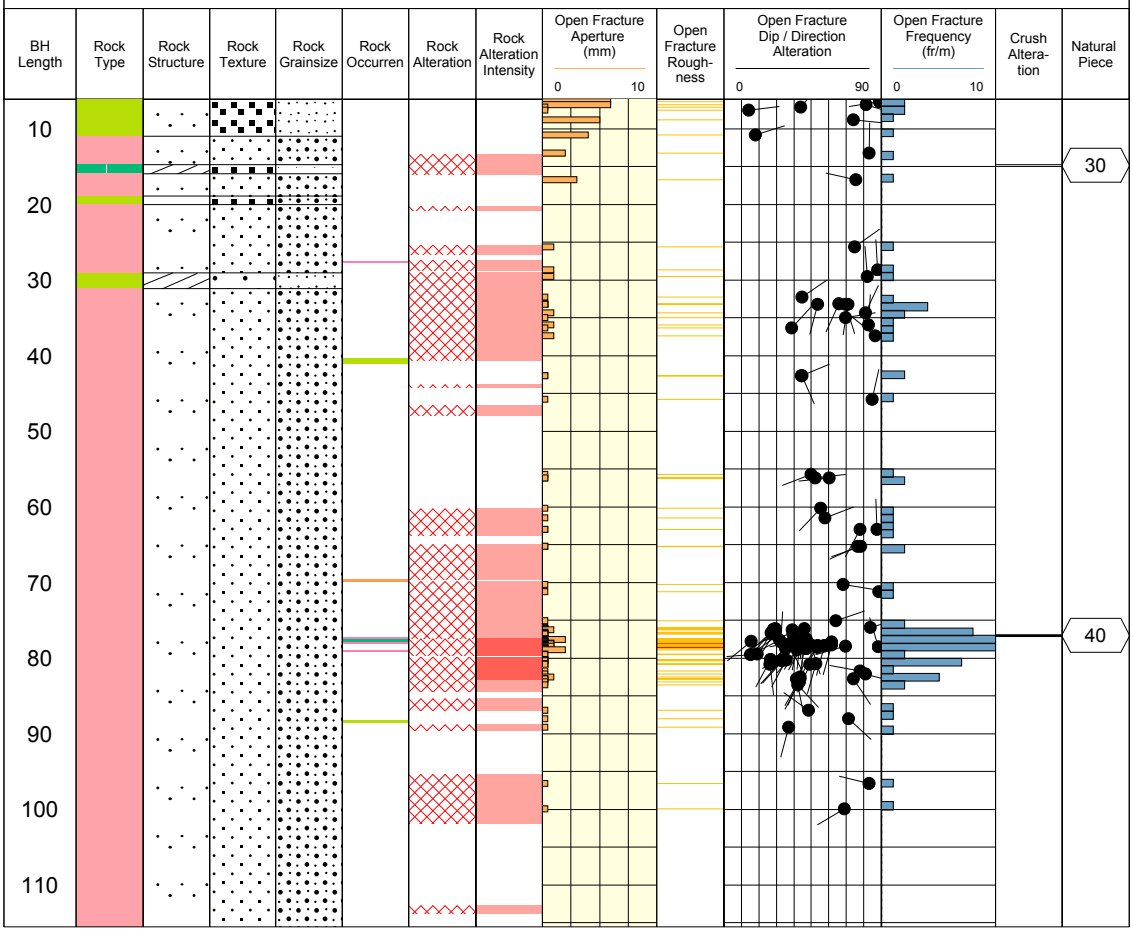
ROCK TEXTURE
- Porphyritic
- Equigranular
- Unequigranular

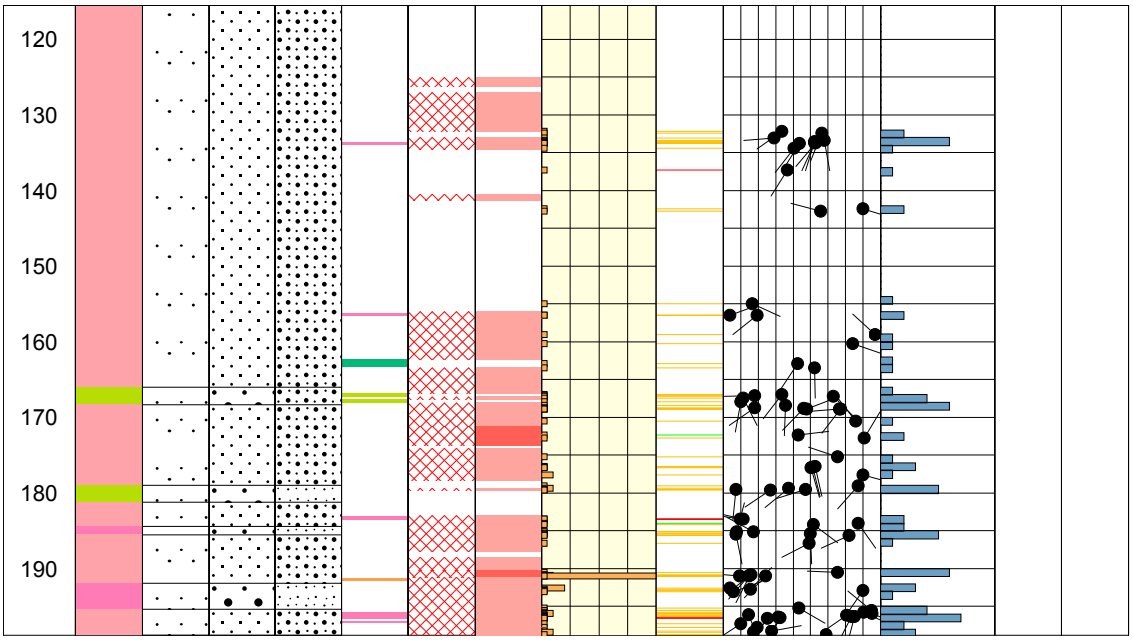
ROUGHNESS
- Planar
- Undulating
- Stepped

ROCK OCCURRENCE
- Fine-grained granite
- Pegmatite
- Diorite / Gabbro
- Fine-grained diorite-gabbro

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

SIMPLIFIED BOREMAP MAPPING

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Simplified geology HLX40

Title SIMPLIFIED GEOLOGY HLX40 **Appendix**

Site	LAXEMAR	**Coordinate System**	RT90-RHB70
Borehole	HLX40	**Northing [m]**	6366906.76
Diameter [mm]	138	**Easting [m]**	1546943.95
Length [m]	199.500	**Elevation [m.a.s.l.]**	25.74
Bearing [°]	11.03	**Drilling Start Date**	2006-05-02 16:15:00
Inclination [°]	-59.81	**Drilling Stop Date**	2006-05-09 12:30:00
Date of mapping	2006-07-04 16:59:00	**Plot Date**	2008-05-07 22:05:06
		Signed data	

ROCKTYPE LAXEMAR
- Fine-grained granite
- Pegmatite
- Ävrö granite
- Diorite / Gabbro

ROCK STRUCTURE
- Massive

ROCK ALTERATION
- Oxidized

INTENSITY
- Weak
- Medium

FRACTURE ALTERATION

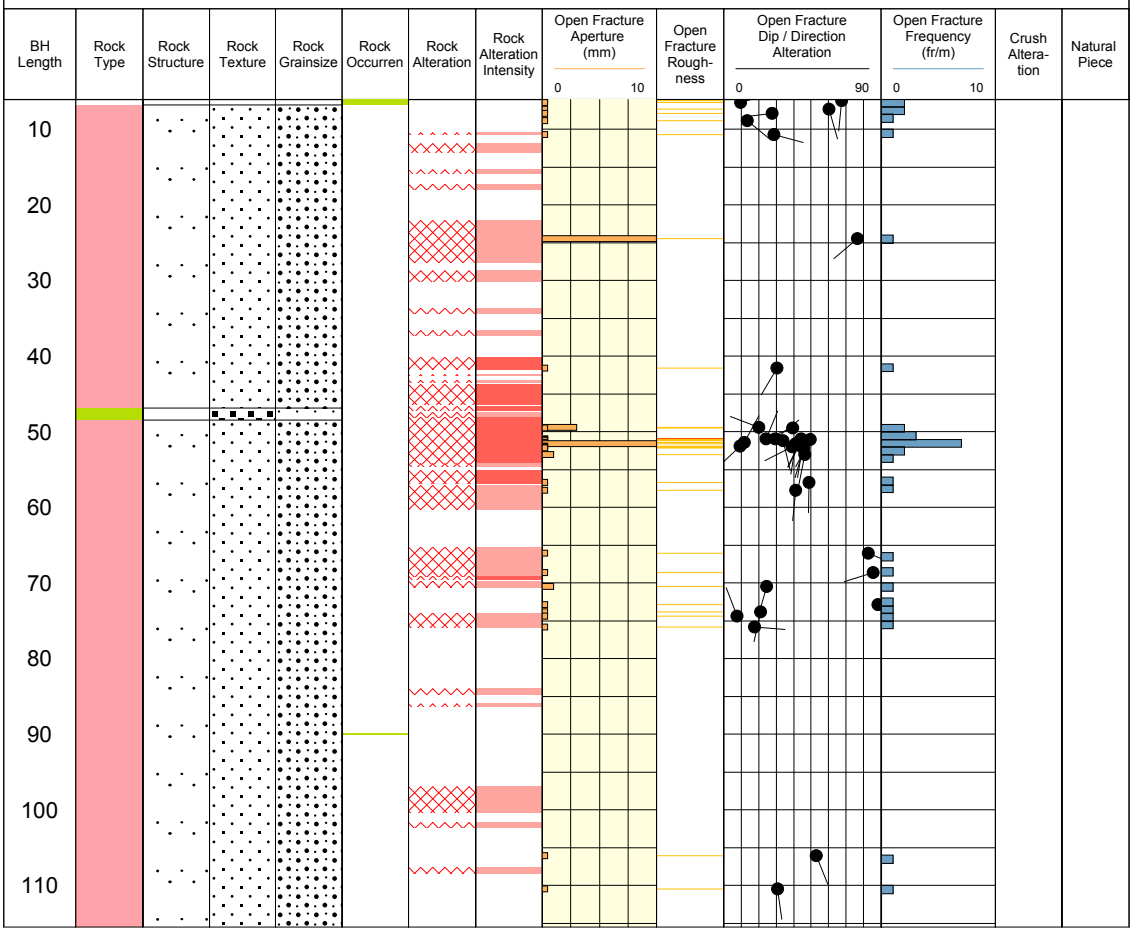
ROCK TEXTURE
- Porphyritic
- Equigranular
- Unequigranular

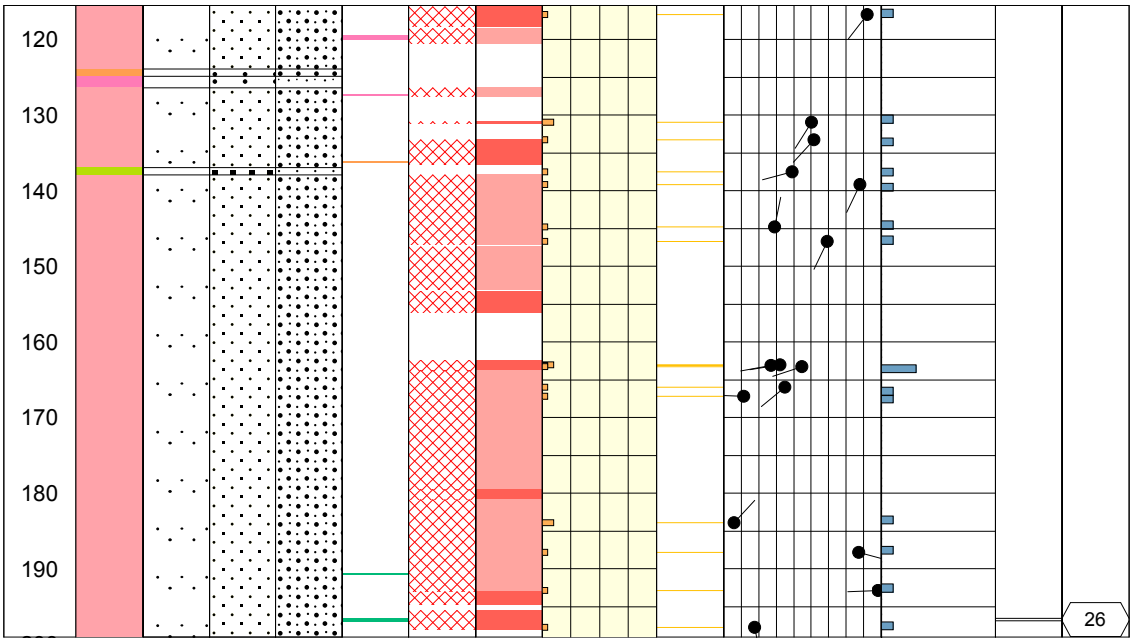
ROUGHNESS
- Planar
- Undulating

ROCK OCCURRENCE
- Fine-grained granite
- Pegmatite
- Diorite / Gabbro
- Fine-grained diorite-gabbro

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

SIMPLIFIED BOREMAP MAPPING

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Simplified geology HLX41

Title SIMPLIFIED GEOLOGY HLX41 **Appendix**

Site	LAXEMAR	**Coordinate System**	RT90-RHB70
Borehole	HLX41	**Northing [m]**	6367013.20
Diameter [mm]	139	**Easting [m]**	1547017.61
Length [m]	199.500	**Elevation [m.a.s.l.]**	21.80
Bearing [°]	208.29	**Drilling Start Date**	2006-05-22 12:00:00
Inclination [°]	-59.14	**Drilling Stop Date**	2006-06-01 11:00:00
Date of mapping	2006-10-11 15:26:00	**Plot Date**	2008-05-07 22:05:06
		Signed data	

ROCKTYPE LAXEMAR
- Fine-grained granite
- Ävrö granite
- Diorite / Gabbro

ROCK STRUCTURE
- Veined
- Massive

ROCK ALTERATION
- Oxidized

INTENSITY
- Weak
- Medium

FRACTURE ALTERATION

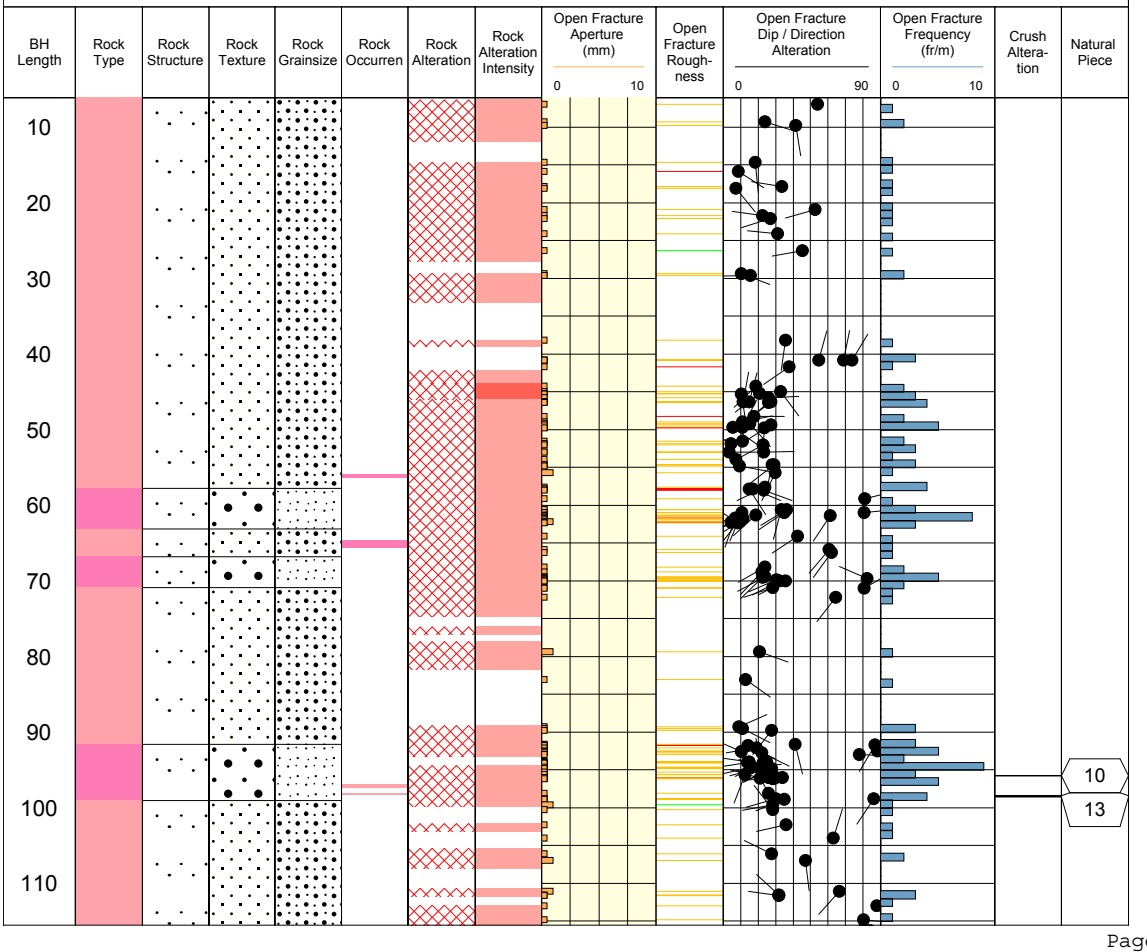
ROCK TEXTURE
- Porphyritic
- Unequigranular

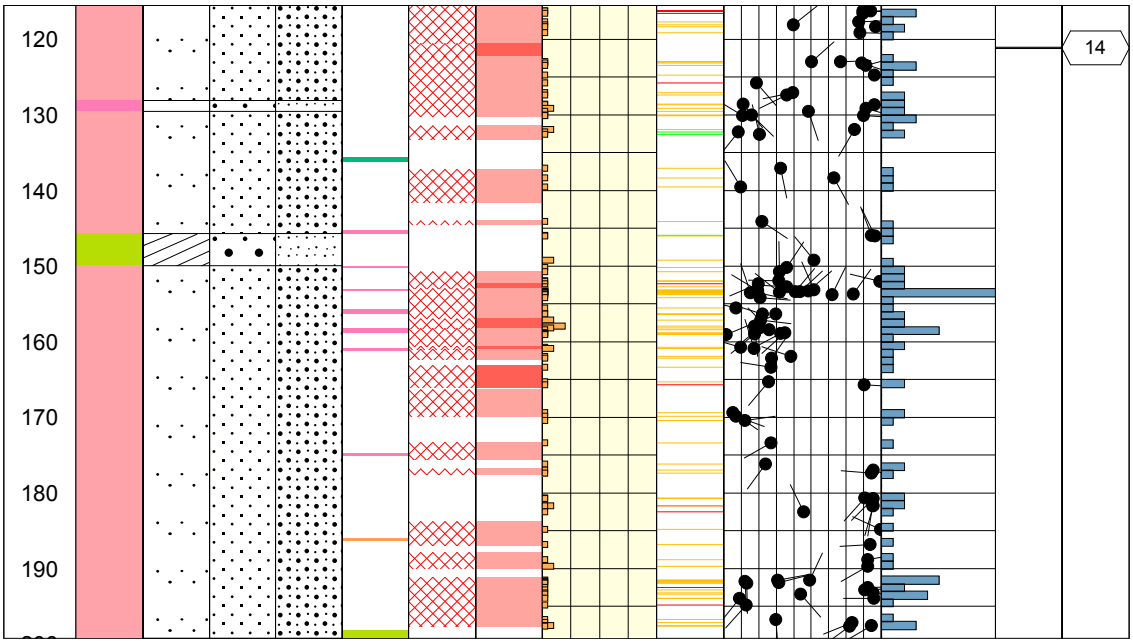
ROUGHNESS
- Planar
- Undulating
- Stepped

ROCK OCCURRENCE
- Fine-grained granite
- Pegmatite
- Ävrö granite
- Diorite / Gabbro
- Fine-grained diorite-gabbro

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

SIMPLIFIED BOREMAP MAPPING

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Simplified geology HLX42

Title SIMPLIFIED GEOLOGY HLX42 **Appendix**

Site	LAXEMAR	**Coordinate System**	RT90-RHB70
Borehole	HLX42	**Northing [m]**	6364827.04
Diameter [mm]	139	**Easting [m]**	1547446.73
Length [m]	152.600	**Elevation [m.a.s.l.]**	12.88
Bearing [°]	321.51	**Drilling Start Date**	2006-11-13 13:30:00
Inclination [°]	-57.20	**Drilling Stop Date**	2006-11-16 19:00:00
Date of mapping	2007-01-31 14:11:00	**Plot Date**	2008-05-07 22:05:06
		Signed data	

ROCKTYPE LAXEMAR
- Fine-grained granite
- Pegmatite
- Quartz monzodiorite
- Fine-grained diorite-gabbro

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

ROCK STRUCTURE
- Veined
- Massive

FRACTURE ALTERATION

ROCK ALTERATION
- Oxidized

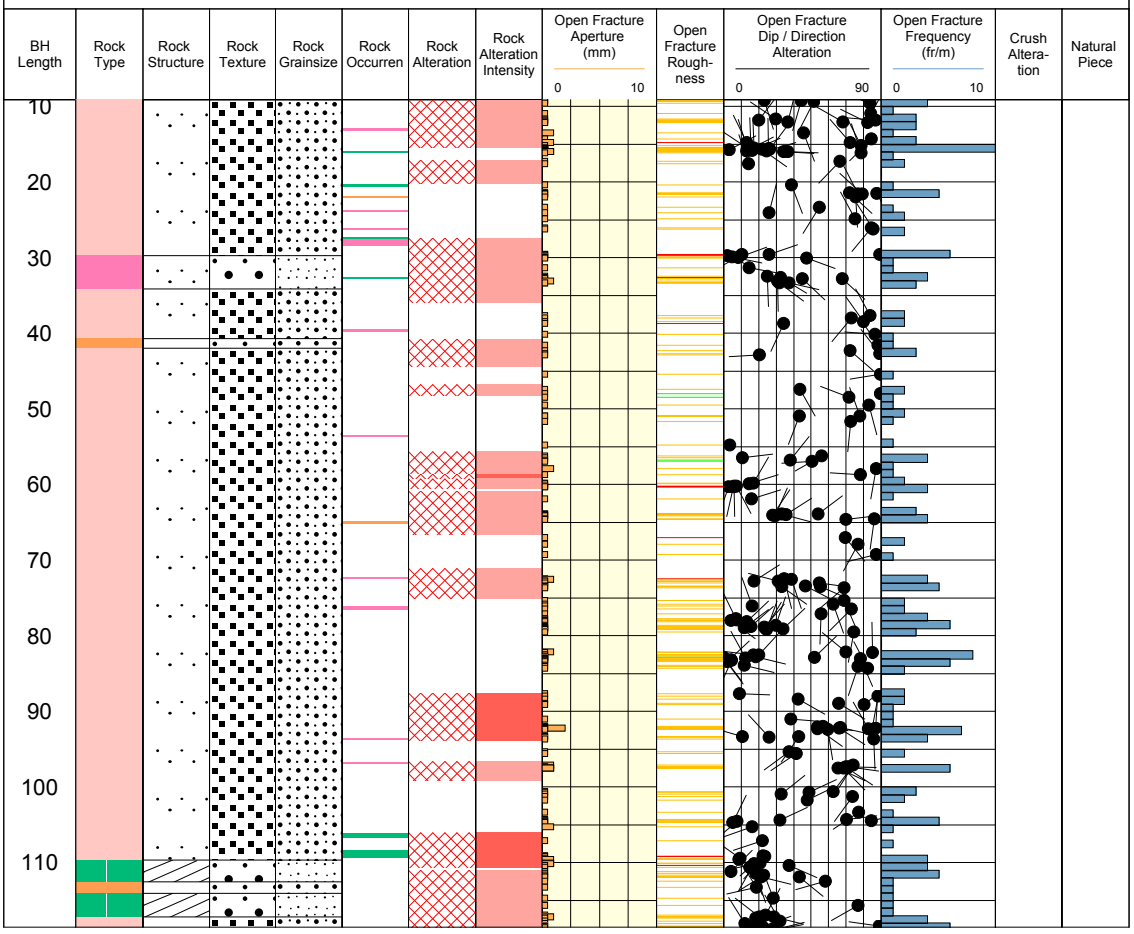
ROCK TEXTURE
- Equigranular
- Unequigranular

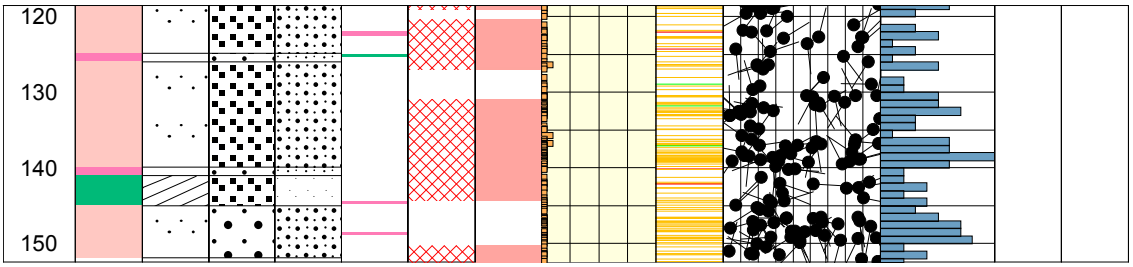
ROCK GRAINSIZE
- Fine-grained
- Fine to medium grained
- Medium to coarse grained
- Coarse-grained

INTENSITY
- Weak
- Medium

ROUGHNESS
- Planar
- Undulating
- Stepped

SIMPLIFIED BOREMAP MAPPING

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Simplified geology HLX43

Title	SIMPLIFIED GEOLOGY HLX43		Appendix
Site	LAXEMAR	Coordinate System	RT90-RHB70
Borehole	HLX43	Northing [m]	6367517.45
Diameter [mm]	140	Easting [m]	1546626.60
Length [m]	170.600	Elevation [m.a.s.l.]	24.20
Bearing [°]	268.55	Drilling Start Date	2006-10-19 15:00:00
Inclination [°]	-50.50	Drilling Stop Date	2006-10-26 10:00:00
Date of mapping	2006-12-05 08:49:00	Plot Date	2008-05-07 22:05:06
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ROCKTYPE LAXEMAR
- Dolerite
- Pegmatite
- Ävrö granite
- Diorite / Gabbro

ROCK STRUCTURE
- Massive

ROCK ALTERATION
- Oxidized

INTENSITY
- Weak
- Medium

ROCK TEXTURE
- Porphyritic
- Equigranular
- Unequigranular

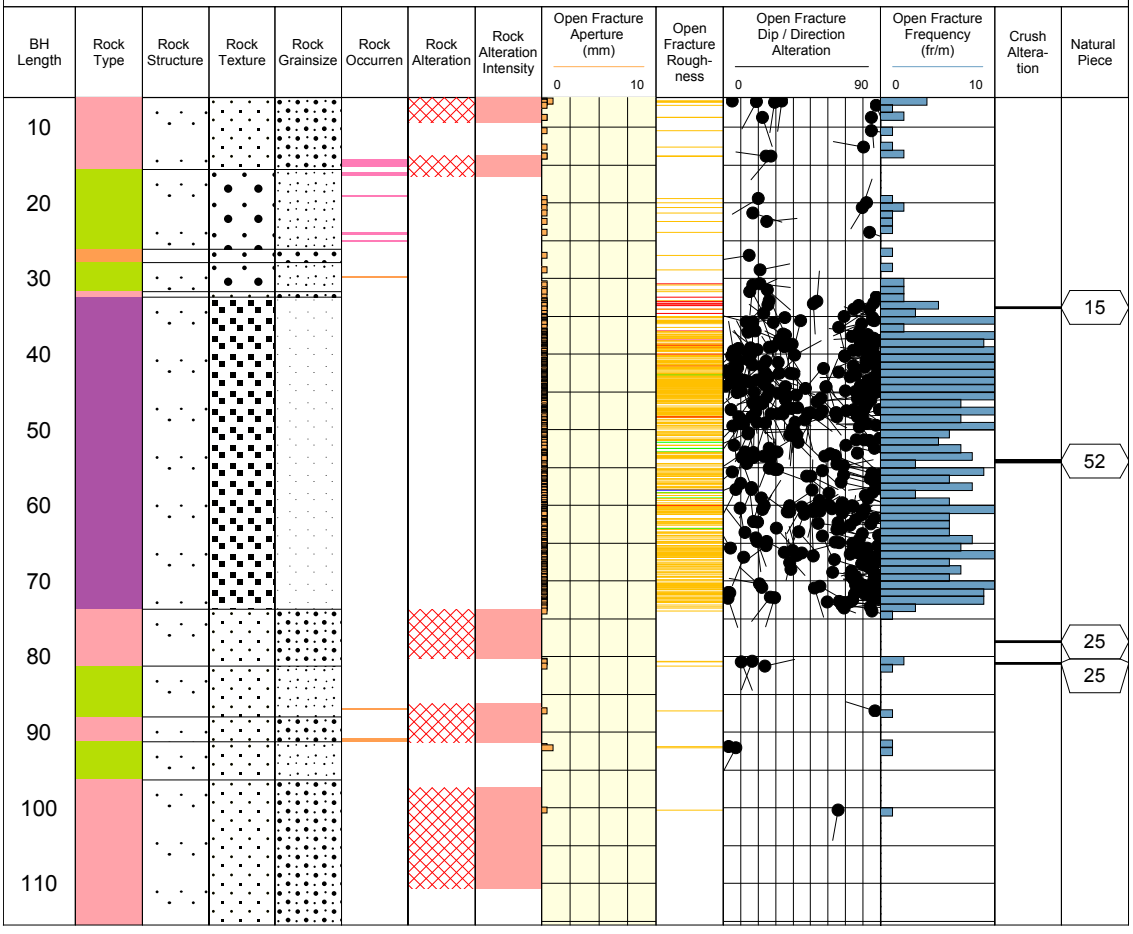
ROUGHNESS
- Planar
- Undulating
- Stepped
- Irregular

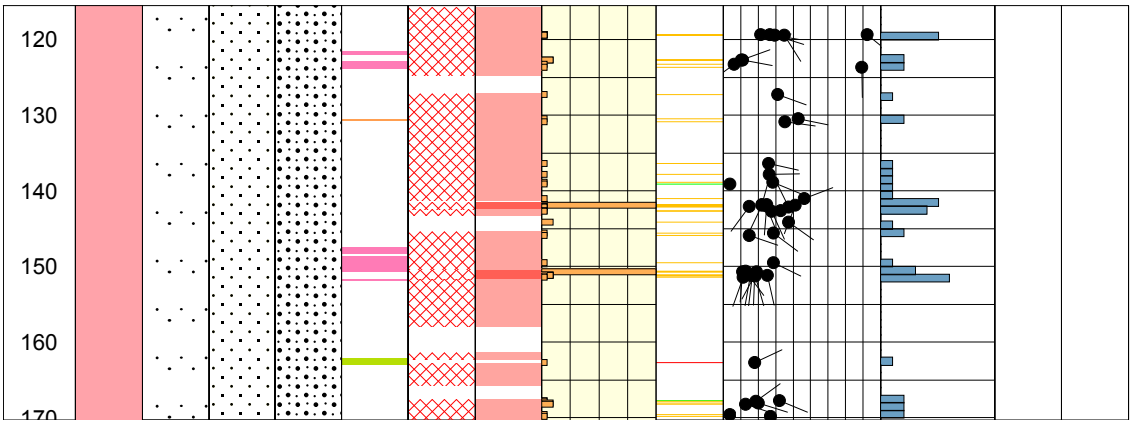
FRACTURE ALTERATION

ROCK OCCURRENCE
- Fine-grained granite
- Pegmatite
- Diorite / Gabbro

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

SIMPLIFIED BOREMAP MAPPING

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