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Oskarshamn site investigation

Simplified Boremap mapping of percussion borehole HLX20 on lineament EW002

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December 2005

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Abstract

Simplified Boremap mapping has been performed for percussion borehole HLX20 situated south of the linked lineament EW002, in the northern part of the Laxemar sub area at the site investigation Oskarshamn, Sweden.

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

The dominating rock type of the mapped borehole is Ävrö granite (approximately 93%), carrying minor amounts of fine-grained diorite-gabbro, all cut by mainly thin dykes of fine-grained granite and occasional pegmatite. Some increase of open fractures is observed at approximately 113 m. BIPS-image becomes opaque because of mud in suspension at 118.3 m. Minor water yielding fractures occur before 82 m length. Alteration occurs mainly in the form of red staining (oxidation), most of the rock is more or less altered, with some indication of increase at approximately 101 m.

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 HLX20 söder om lineament EW002 i norra delen av delområde Laxemar, vid platsundersökningen Oskarshamn.

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

Den dominerande bergarten i det karterade borrhålet är Ävrögranit (ca 93 %), den innehåller mindre mängder av finkornig diorit-gabbro, allt klipps av i huvudsak tunna gångar bestående till största delen av finkornig granit och enstaka pegmatit. Någon ökning av antalet öppna spricker observerades vid ca 113 m. BIPS-bilden blir ogenomskinlig på grund av grumlighet vid 118,3 m. Svagt vattenförande spricker förekommer innan 82 m. Omvandling förekommer i huvudsak som rödfärgning (oxidering), det mesta av berget är mer eller mindre omvandlad, med viss indikering av ökning vid ca 101 m.

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

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1 Introduction

To investigate the linked, east-west trending lineament with the designation EW002 in the northern part of the Laxemar sub area of the Oskarshamn site investigation, see Figure 1-1, one percussion borehole was drilled in June 2004 /1/.

This document reports data gained by Simplified Boremap mapping of percussion borehole HLX20 in June 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). Using the preliminary mapping of drill cuttings /1/ for comparison (see Chapter 4.1), 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.

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 HLX20, HLX28 to HLX32 and HLX15 is included in activity plan AP PS 400-04-124.

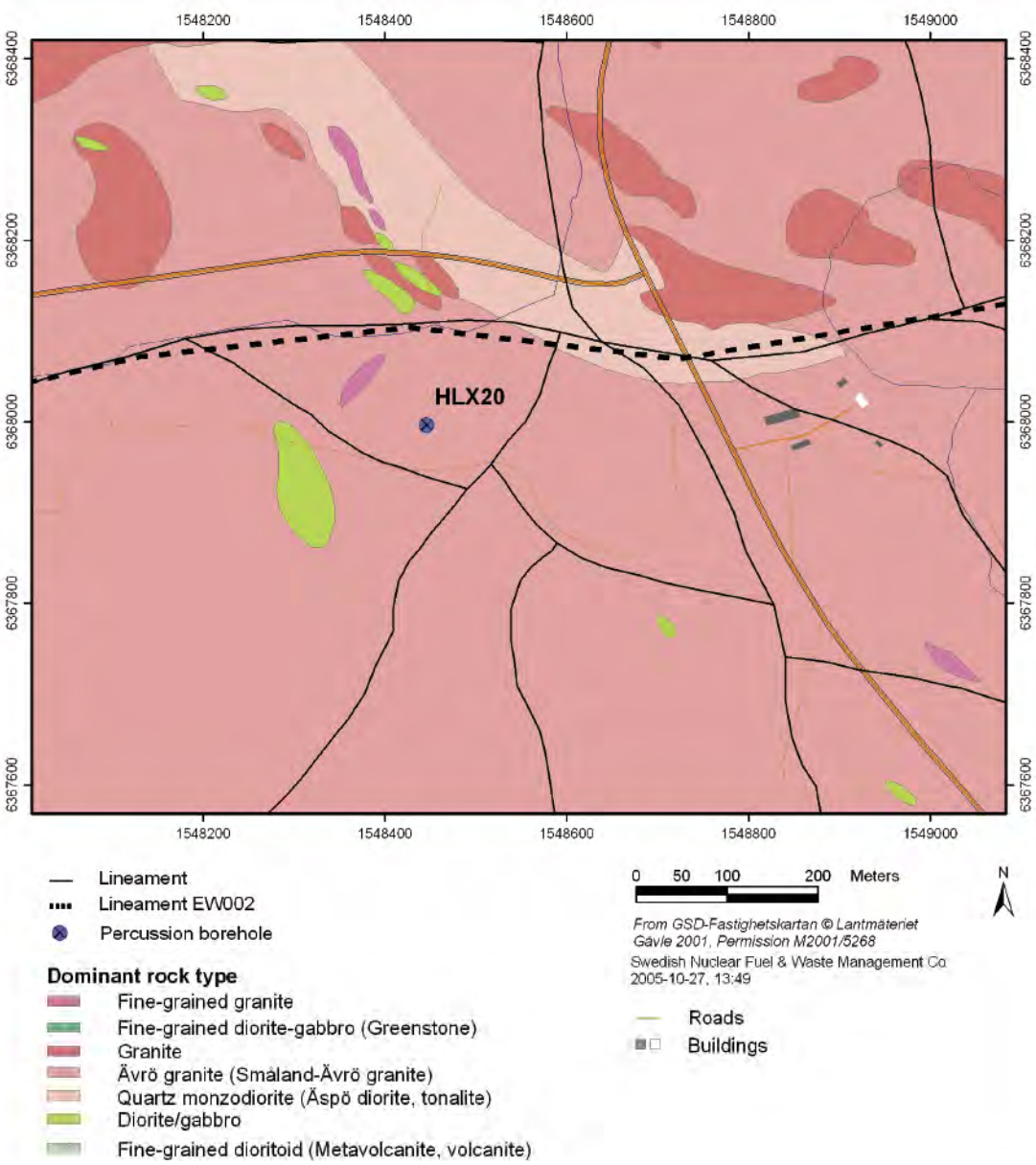

Figure 1-1. *Location of borehole HLX20 in the Laxemar sub area. The map shows the bedrock geology, lineament EW002, linked lineaments, roads and houses.*

2 Objective and scope

The purpose of this survey is to map the lithology and structural parameters of percussion borehole HLX20 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 3.4.5), 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; borehole HLX20 is of relatively good quality, mud covers the lowermost part of the borehole wall but it does not affect the visibility more than marginally. Mud covers approximately 50% of the borehole wall at approximately 115 m and at ca 118.3 m the BIPS-image becomes totally opaque (no visibility at all) because of mud in suspension, see Figure 3-2.

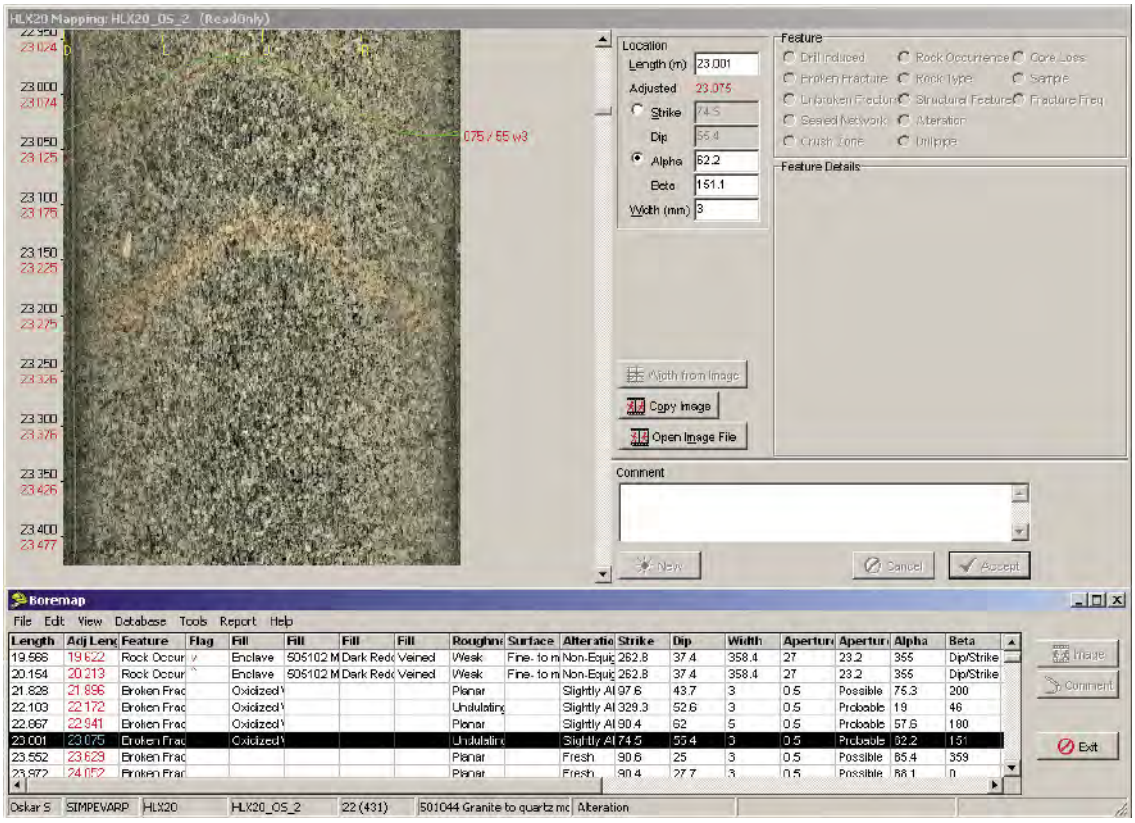

Figure 3-1. *Good quality BIPS-image as it is seen in Boremap. Borehole HLX20, showing unaltered (fresh), medium to coarse grained, massive Ävrö granite with one open fracture with oxidized walls marked (green line) and one possible fracture with oxidized walls, unmarked.*

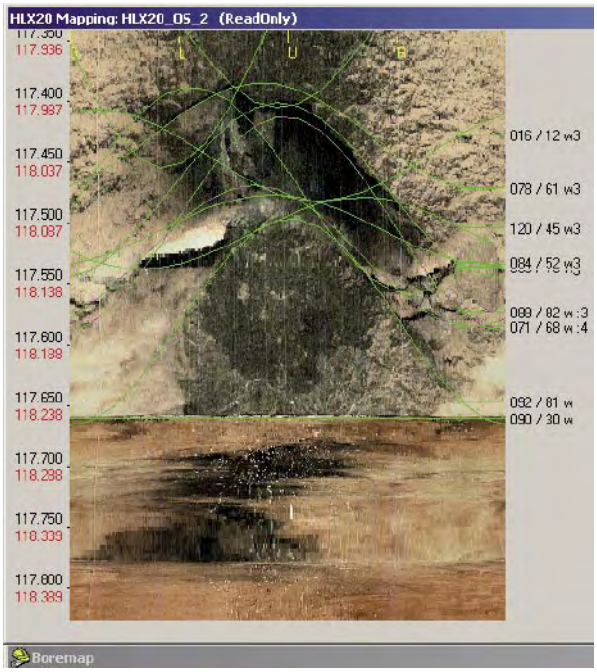

Figure 3-2. *BIPS-image as seen in Boremap of borehole HLX20 between ca 117.9–118.4 m (adj. length). No visibility at all because of muddy water from approximately 118.248 m (adj. length).*

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/
- results from percussion drilling /1/
- available geophysical measurements and interpretations

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).

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 the starting point of the borehole is used for the whole length as no measurements of borehole deviation have been made.

Table 4-1. Borehole data for HLX20 (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)
HLX20	6367996.256	1548446.085	0.405	–60.384	138	202.2	9.12	9.12–118.6

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:

- 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 of the rock, but usually not a problem when drill cuttings and 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 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. From approximately 117.66 m (measured length) to end of BIPS-image at approximately 129.99 m (measured length) there is no visibility because of muddy water and the BIPS-image is therefore not mapped below 117.66 m (118.25 m adjusted length).

5 Results

Below the results from mapping of lithology, alteration and open fractures are given for borehole HLX20. The percentages of different lithologies are given in Table 5-1. The amount of alteration (oxidation) and intensity is listed in Table 5-2 and finally the number of open fractures and the fracture frequency per meter can be seen in Table 5-3.

HLX20

See Appendix 1 for WellCAD presentation of mapping results.

Lithology: The dominant rock type is Ävrö granite, see Figure 3-1, containing fragments and/or enclaves of fine-grained diorite-gabbro, all cut by dykes and veins of fine-grained granite and pegmatite, see Table 5-1 and Figure 5-1.

Table 5-1. Lithology of borehole HLX20. Percents calculated from adjusted length of BIPS-image.

Rock name	SKB rock code	%
Ävrö granite	501044	92.6
Fine-grained diorite-gabbro	505102	4.3
Fine-grained granite	511058	2.6
Pegmatite	501061	0.5

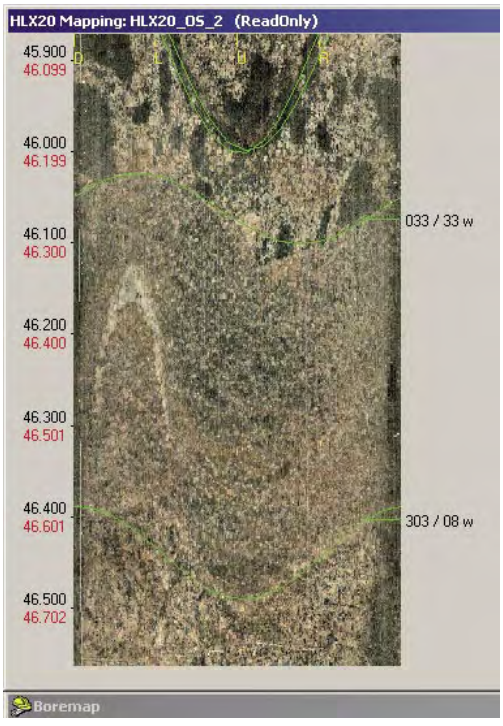

Figure 5-1. *BIPS-image as seen in Boremap of borehole HLX20 between approximately 45.9–46.6 m. Weakly altered (oxidized) and somewhat porphyritic Ävrö granite containing fine-grained diorite-gabbro fragments is cut by a fine-grained granite dyke. Two open fractures are marked with green lines, as well as the borders of the dyke.*

Alteration: Approximately 93% of the rock shows some alteration. Mostly weak, but medium intensity occurs also, see Table 5-2. At approximately 101 m length an increase in the intensity of alteration can be seen.

Open fractures: The number of mapped open fractures is 354 resulting in an average of 3.23 per metre, see Table 5-3. Some increase in fracture frequency can be noted below approximately 113 m length. Open fractures that yield water occur somewhere above 81.9 m yielding approximately 5.5 l/min /1/. This could be any or all of the three open fractures mapped in the BIPS-image, the crush zone at 10.6 m, the open fractures at 48.5 m, see Figure 5-2 and the open fracture at 76.8 m. The crush zone marked at 117.5 m is at least 11cm wide, but it is at the bottom of the visible BIPS-image so it could be wider. The rock seems to be of worse quality below approximately 117 m and to the end of the borehole /1/, but the BIPS-image ends at 117.7 m (118.3 adjusted length).

Table 5-2. Total alteration seen in BIPS-image of percussion borehole HLX20.

Alteration	Intensity	HLX20 (%)
Oxidation	Weak	67
	Medium	26

Table 5-3. Total number of open fractures in BIPS-image of percussion borehole HLX20.

	Total number of open fractures	Fractures/meter
HLX20	354	3.23

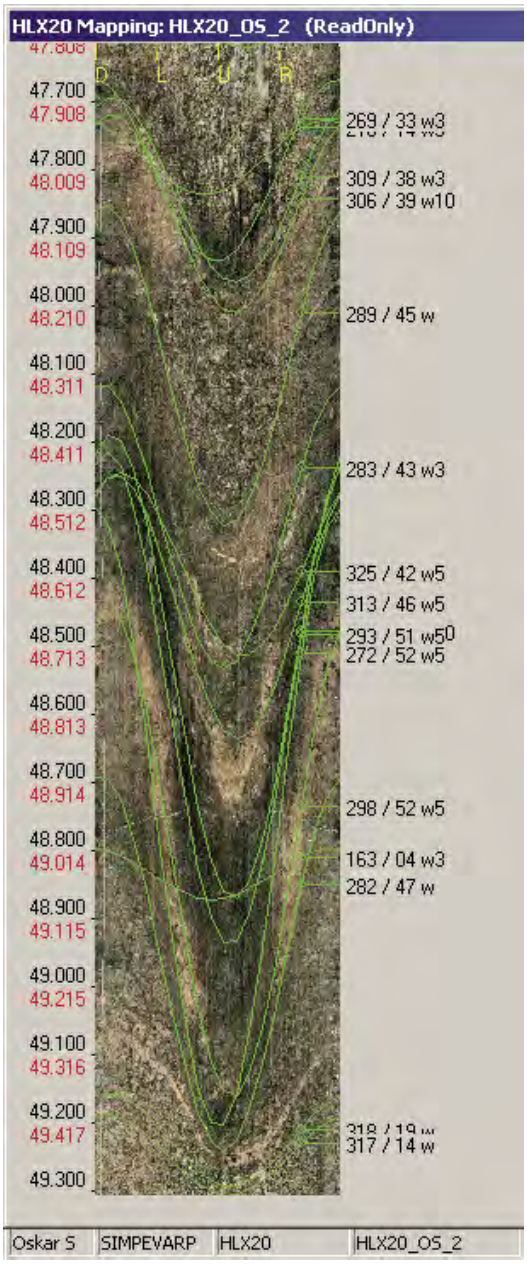

Figure 5-2. *BIPS-image as seen in Boremap of borehole HLX20 between approximately 47.7–49.3 m. Medium altered (oxidized) and somewhat porphyritic Ävrö granite cut by fine-grained granite. Several open fractures (possibly water yielding) are marked with green lines, as well as the borders of the dyke.*

6 Summary and discussions

The lithology dominating the BIPS-image of borehole HLX20 is Ävrö granite. It shows some increase in fracture frequency below approximately 113 m associated with intensification of the red staining (alteration). This indicates weakness in the rock, but it is not until it is seen together with the Penetration rate and Magnetic Susceptibility /1/ that it can be connected to the deformational zone EW002.

The borehole cuts through water yielding zones, the main one being at approximately 178 m length /1/, while the BIPS-image is only 117.7 m long (adjusted length 118.3 m). There is a minor water yielding zone or zones above 82 m, but it is not certain exactly where since three possibilities seem plausible from the BIPS-image. The existence of water yielding open 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 borehole.

No deviation measurements were conducted for HLX20 so the measurements from top of casing are used for the entire length of the borehole.

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.

References

/1/ **Ask H, Samuelsson L-E, 2004.** Oskarshamn site investigation. Percussion drilling of borehole HLX20 for investigation of lineament EW002. SKB P-04-236.

Simplified geology HLX20

Title SIMPLIFIED GEOLOGY HLX20 **Appendix** 1

Site	LAXEMAR	**Coordinate System**	RT90-RHB70
Borehole	HLX20	**Northing [m]**	6367996.26
Diameter [mm]	138	**Easting [m]**	1548446.09
Length [m]	202.200	**Elevation [m.a.s.l.]**	11.18
Bearing [°]	0.41	**Drilling Start Date**	2004-06-15 09:30:00
Inclination [°]	-60.37	**Drilling Stop Date**	2004-06-21 12:00:00
Date of mapping	2005-06-27 13:10:00	**Plot Date**	2005-11-16 00:24:47

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

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

ROCK STRUCTURE
- Veined
- Massive

FRACTURE ALTERATION
- Slightly Altered
- Moderately Altered
- Fresh

ROCK ALTERATION
- Oxidized

ROCK TEXTURE
- Porphyritic
- Unequigranular

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

INTENSITY
- Weak
- Medium

ROUGHNESS
- Planar
- Undulating
- Stepped