P-04-133

Revised June 2006

Oskarshamn site investigation

Geological single-hole interpretation of KSH02 and KAV01

Håkan Mattsson, GeoVista AB
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April 2004

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April 2004

Keywords: Geophysics, Rock unit, Borehole, Deformation zone, Fractures, Alteration.

Reading instruction

For revision no. 1 of this report a recalculation of the directional radar data has been done. The strike and angel between the line of the plan's cross-section with the surface and the Magnetic North direction was earlier counted counter-clockwise but it is now recalculated as such it counts clockwise. New values for strike and dip are therefore updated in Chapter 5.

Sammanfattning

Denna rapport behandlar geologisk enhålstolkning av kärnborrhålen KSH02 på Simpevarpshalvön och KAV01 på Ävrö. Den geologiska enhålstolkningen syftar till att utifrån data från den geologiska kärnkarteringen, tolkade geofysiska loggar, borrhålsradarmätningar indikera olika litologiska enheters fördelning samt möjliga deformationszoners läge och utbredning längs borrhålet.

Undersökningen visar att det i KSH02 finns tre olika litologiska enheter. Generellt sett dominerar bergarten finkornig dioritoid litologin i hela borrhålet. Fin- till medelkornig granit, pegmatit och finkornig mafisk bergart förekommer i mindre omfattning. Tre möjliga större deformationszoner identifieras i KSH02.

För KAV01 indikeras 7 olika litologiska enheter och en möjlig större deformationszon. Den dominerande bergarten i borrhålet är Ävrögranit. En litologisk enhet domineras av finkornig dioritoid. I övrigt förekommer finkornig dioritoid, finkornig mafisk bergart, fin till medel och grovkornig granit i meterlånga sektioner längs vissa delar av hålet. Längs hela de nedersta 320 m av hålet tycks stora delar av berget ha påverkats av varierande grad av omvandling.

Contents

1 Introduction

Much of the primary geological and geophysical borehole data stored in the SKB database SICADA need to be integrated and synthesized before they can be used for modeling in RVS. The end result of this procedure is a geological single-hole interpretation, which consist of integrated series of different loggings and accompanying descriptive documents (SKB MD 810.003, SKB internal controlling document). The controlling documents for performing this activity are listed in Table 1-1. Both activity plan and method description are SKB's internal controlling documents. Rock type nomenclature that has been used is shown in Table 1-2.

This document reports the geological single-hole interpretation, for the cored boreholes KSH02 at the Simpevarp peninsula and KAV01 at the Ävrö Island (Figure 1-1).

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

Activity plan	**Number**	**Version**
Geologisk enhålstolkning av KSH02 och KAV01	AP PS 400-04-037	1.0
Method description	**Number**	**Version**
Metodbeskrivning för geologisk enhålstolkning	SKB MD 810.003	1.0

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. *Map showing the position of the cored boreholes KSH02 and KAV01.*

2 Objective and scope

The single-hole interpretation is performed in order to make a generalized classification of major lithological units and possible major deformation zones within the borehole. The classification is performed manually by a combined interpretation of the logging data from the geological core mapping (Boremap), different geophysical loggings and borehole radar data. The results are presented as two logs, one indicating the lithological unit (RU) and other possible deformation zones (DZ).

3 Data used for the single-hole interpretation

The data used for the single-hole interpretation are

- Boremap (including BIPS and core mapping data) /1, 2/.
- Generalized geophysical loggings (interpretation of geophysical logging data) /3/.

4 Execution of the single-hole interpretation

The single-hole interpretation method is an integrated interpretation of the information from three sources, and these are the boremap investigation, geophysical loggings and borehole radar data. The interpretation is performed by a group of experts consisting of at least one geologist and one geophysicist.

All data to be used (see above) are visualized side by side in a borehole document in the software WellCAD (see Appendices 1 and 2).

Step 1 is to manually (visually) go through the rock-type related logging data and merge sections of similar rock types, or sections where one rock type is very dominant, to major lithological units (minimum length of ca 5 m). Even so the fracture frequency and ductile deformation are included in the interpretation of rock units. All the interpretation is based on geophysical logging data, boremap data and BIPS.

Step 2 is to identify possible major deformation zones by visual inspection of the fracture frequency loggings, alteration loggings and radar loggings. The section of each identified possible deformation zone is indicated and shortly described in text.

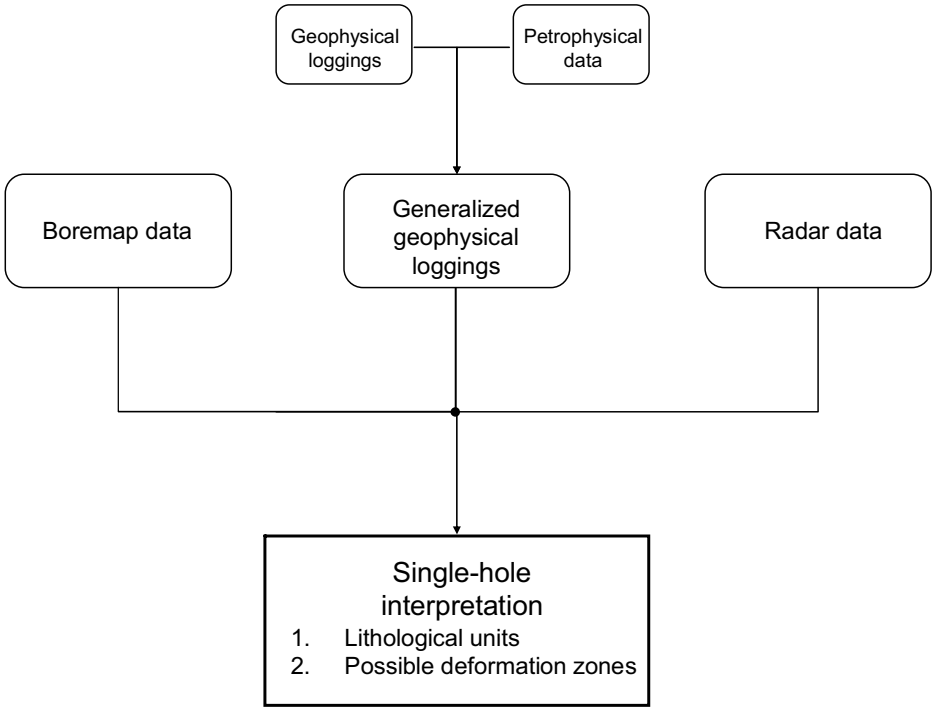


Figure 4-1. *Schematic block-scheme of single-hole interpretation.*

4.1 Nonconformities

For revision no. 1 of this report a recalculation of the directional radar data has been done. The strike and angel between the line of the plan's cross-section with the surface and the Magnetic North direction was earlier counted counter-clockwise but it is now recalculated as such it counts clockwise. New values for strike and dip are therefore updated in Chapter 5.

5 Results

The detailed results of the single-hole interpretations are presented as print-outs from the software WellCad (Appendix 1 for KSH02 and Appendix 2 for KAV01). Orientations from directional radar are presented as dip/strike using the right-hand rule.

5.1 KSH02

Three rock units are indicated:

Rock unit 1: 80-ca 470 m

Rock unit completely dominated by fine-grained dioritoid (fine-grained, intermediate, magmatic rock) with a few < 5 m long sections of pegmatite. Furthermore, a few scattered thin sections of fine- to medium-grained granite occur. Increased sealed fracturing.

Rock unit 2: ca 470-743 m

Rock unit characterized by a mixture of fine-grained dioritoid (fine-grained, intermediate, magmatic rock) and up to 20 m long sections of fine- to medium-grained granite. Furthermore, a few < 4 m long sections of pegmatite occur. Increased sealed fracturing.

Rock unit 3: ca 743-1000 m

Rock unit very similar to rock unit 1., i.e. completely dominated by fine-grained dioritoid (fine-grained, intermediate, magmatic rock). An exception is a ca 10 long section of fine-grained diorite to gabbro (fine-grained, mafic rock) between ca 970 and 980 m.

Three possible major deformation zones are indicated:

Deformation zone 1: ca 233-304 m

Increased fracturing and strong alteration (280-304 m) indicated by low density, low P-wave velocity, low resistivity, low magnetic susceptibility and Boremap data. Oriented radar reflectors occur at 294.8 m with the orientation 31/006 and at 302.2 m with the orientation 34/072.

Deformation zone 2: ca 511-532 m

Strong alteration indicated by low resistivity, low magnetic susceptibility and Boremap data. Oriented radar reflectors occur at 519.4 m with the orientation 69/051 and at 523.8 m with the orientation 77/237.

Deformation zone 3: ca 654-681 m

Medium to strong alteration and increased fracturing, mainly indicated by Boremap data. Only sparse indications in geophysical loggings. Oriented radar reflectors occur at 656.3 m with the orientation 22/282, at 678.3 m with the orientation 40/093 and at 679.6 m with the orientation 33/279.

5.2 KAV01

Seven rock units are indicated:

Rock unit 1: ca 20-135 m

Rock unit dominated by Ävrö granite (granite to quartz monzodiorite) with subordinate sections of fine- to medium-grained granite and fine-grained diorite to gabbro (fine-grained mafic rock).

Rock unit 2: ca 135-185 m

Rock unit dominated by fine-grained dioritoid (fine-grained, intermediate, magmatic rock), with < 4 m long sections of fine-grained diorite to gabbro (fine-grained mafic rock) and subordinate sections of Ävrö granite (granite to quartz monzodiorite). Section 135-160 m is dominated by high density and low gamma radiation, whereas section 160-185 m is dominated by low density and higher gamma radiation.

Rock unit 3: ca 185-364 m

Rock unit very similar to rock unit 1. Completely dominated by Ävrö granite (granite to quartz monzodiorite), with a few thin sections of fine- to medium-grained granite.

Rock unit 4: ca 364-494 m

Rock unit dominated by Ävrö granite (granite to quartz monzodiorite) with a few < 5 m long sections of fine- to medium-grained granite, fine-grained diorite to gabbro (fine-grained mafic rock), medium- to coarse-grained granite and fine-grained dioritoid (fine-grained, intermediate, magmatic rock).

Rock unit 5: ca 494-605 m

Rock unit very similar to rock units 1 and 3. Completely dominated by Ävrö granite (granite to quartz monzodiorite).

Rock unit 6: ca 605-686 m

Rock unit slightly dominated by Ävrö granite (granite to quartz monzodiorite) with up to 10 m long sections of fine-grained dioritoid (fine-grained, intermediate, magmatic rock) and fine- to medium-grained granite and subordinate medium- to coarse-grained granite.

Rock unit 7: 686-750 m

Rock unit very similar to rock units 1, 3 and 5. Completely dominated by Ävrö granite (granite to quartz monzodiorite).

One possible major deformation zone is indicated:

Deformation zone 1: ca 426-565 m

The zone is characterized by increased fracturing and weak to medium alteration, indicated by low resistivity, low magnetic susceptibility and Boremap data. Increased fracturing in the interval 426-437.5 m. Alteration, low susceptibility and resistivity in the interval 437.5-464 m. Increased fracturing, low density and susceptibility in the interval 464-565 m. Medium to strong alteration is indicated in the section ca 431-464 m. The section ca 520-565 m seems to be heavily fractured. Eight oriented borehole radar reflectors occur within DZ1. At 438.6 m with the orientation 36/294, at 444.5 m with the orientation 35/273, at 447.3 m with the orientation 88/114, at 453.5 m with the orientation 37/087, at 479.7 m with the orientation 62/243, at 489.4 m with the orientation 44/078, at 532.2 m with the orientation 20/054 and at 554.0 m with the orientation 24/312.

7 Comments

The geophysical loggings normal resistivity and SPR indicate that major parts of the lowermost 320 m of KAV01 (section ca 430-750 m) are affected by various degrees of alteration.

In KSH02 and in KAV01 the radar measurements were performed with a directional antenna (giving dip and strike direction of reflectors).

8 References

/1/ **Ehrenborg J, Steiskal V, 2004.** Boremap mapping of the telescopic drilled borehole KAV01. SKB P-04-130. Svensk Kärnbränslehantering AB.

/2/ **Ehrenborg J, Steiskal V, 2004.** Boremap mapping of the telescopic drilled borehole KSH02. SKB P-04-131. Svensk Kärnbränslehantering AB.

/3/ **Mattsson H, Thunehed H, 2004.** Interpretation of geophysical borehole data and compilation of petrophysical data from KSH02 (80-1000 m) and KAV01. SKB P-04-77. Svensk Kärnbränslehantering AB.

Geological single-hole interpretation for KSH02

Appendix 1

Title	SINGLE HOLE INTERPRETATION KSH02					
	Site	SIMPEVARP	**Inclination [°]**	-85.74	**Elevation [m.a.s.l.]**	5.41
	Borehole	KSH02	**Date of mapping**	2003-07-03 14:32:00	**Drilling Start Date**	2003-01-22 07:00:00
	Diameter [mm]	76	**Coordinate System**	RT90-RHB70	**Drilling Stop Date**	2003-03-03 19:00:00
	Length [m]	1001.110	**Northing [m]**	6365657.51	**Surveying Date**	
	Bearing [°]	329.99	**Easting [m]**	1551528.98	**Plot Date**	2006-04-02 21:14:58

Signed data

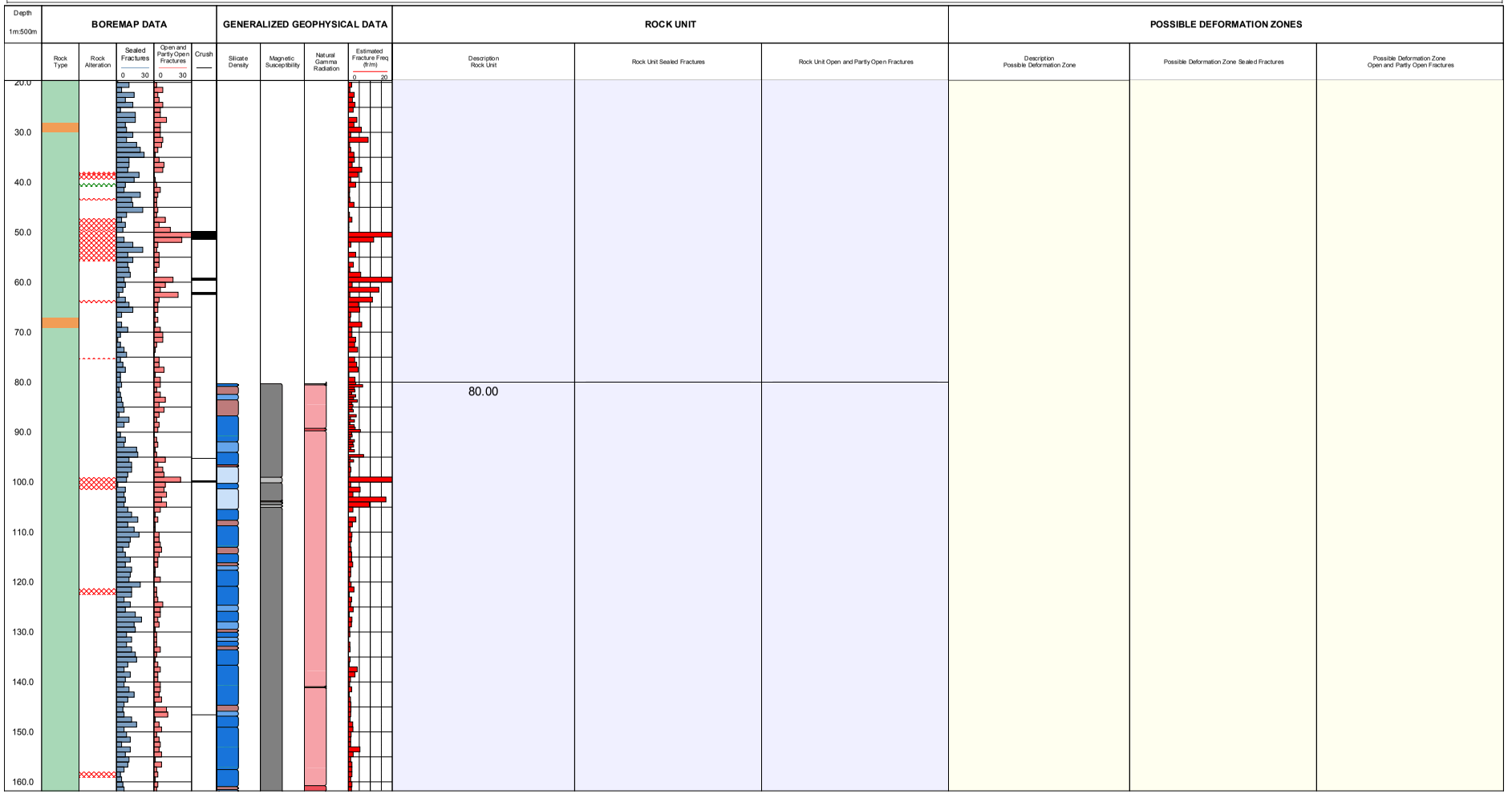
ROCKTYPE SIMPEVARP
- Fine-grained granite
- Pegmatite
- Fine-grained dioritoid
- Fine-grained diorite-gabbro

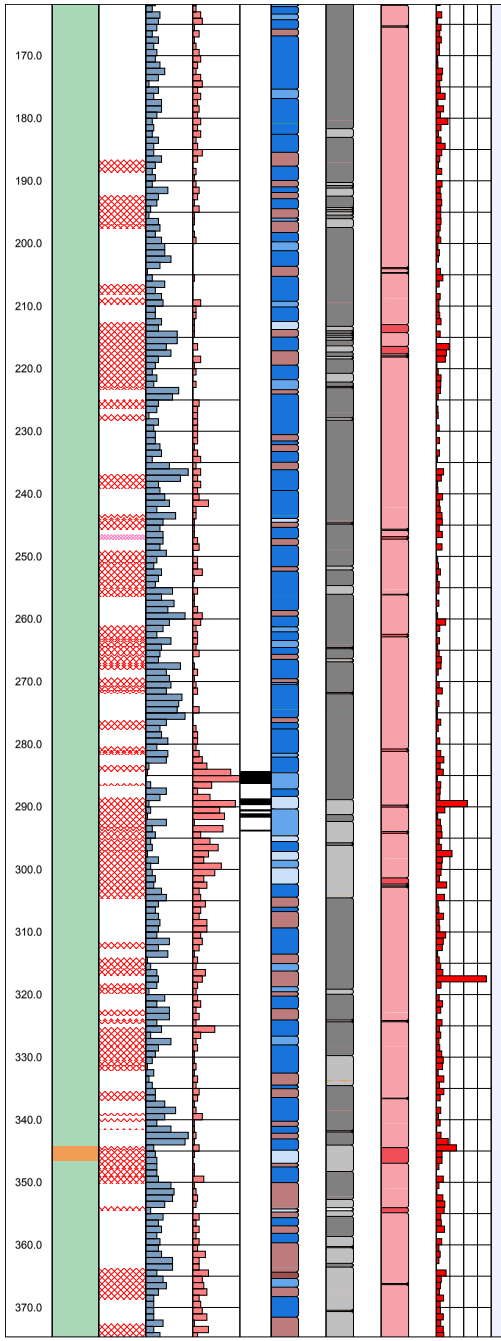
ROCK ALTERATION
- Oxidized
- Chloritisized
- Albitization

SILICATE DENSITY
- dens<2680 (Granite)
- 2680<dens<2730 (Granodiorite)
- 2730<dens<2800 (Tonalite)
- 2800<dens<2890 (Diorite)
- dens>2890 (Gabbro)

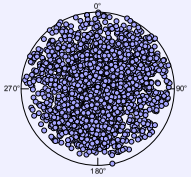
SUSCEPTIBILITET
- sus<0.001
- 0.001<sus<0.01
- 0.01<sus<0.1

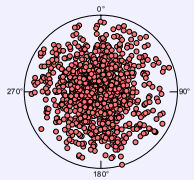
NATURAL GAMMA
- gam<10
- 10<gam<25
- gam>25





RU1
Rock Unit 1: Rock unit completely dominatedby fine-grained dioritoid (fine-grained, intermediate,magmatic rock) with a few < 5 m long sections of pegmatite.Furthermore, a few scattered thin sections of fine- to medium-grainedgranite occur. Sealed fracture frequency very high!

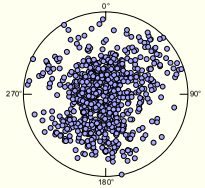


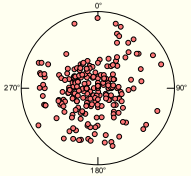


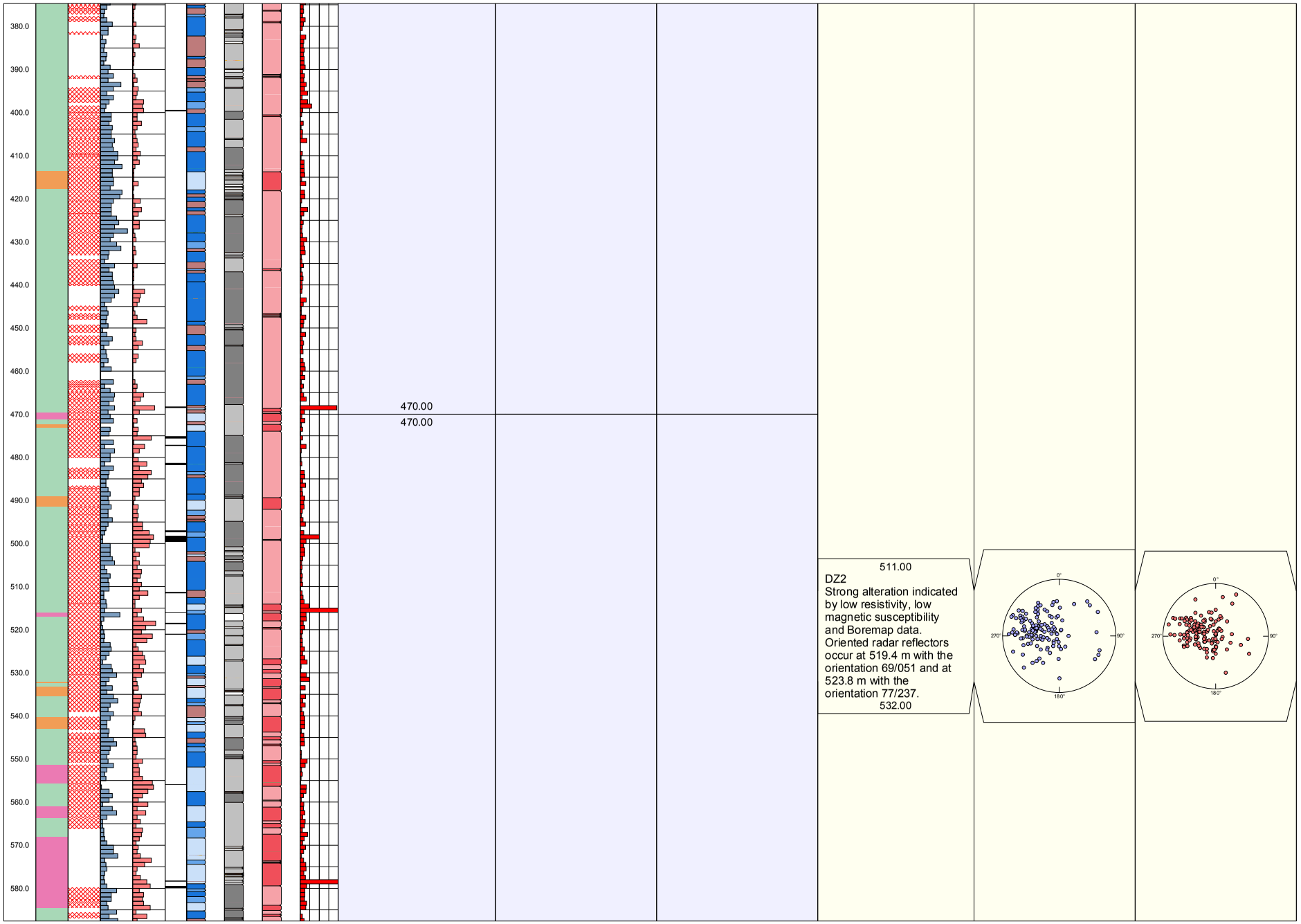
233.00

DZ1
Increased fracturing and strong alteration (280-304 m) indicated by low density, low P-wave velocity, low resistivity, low magnetic susceptibility and Boremap data. Oriented radar reflectors occur at 294.8 m with the orientation 31/006 and at 302.2 m with the orientation 34/072.

304.00



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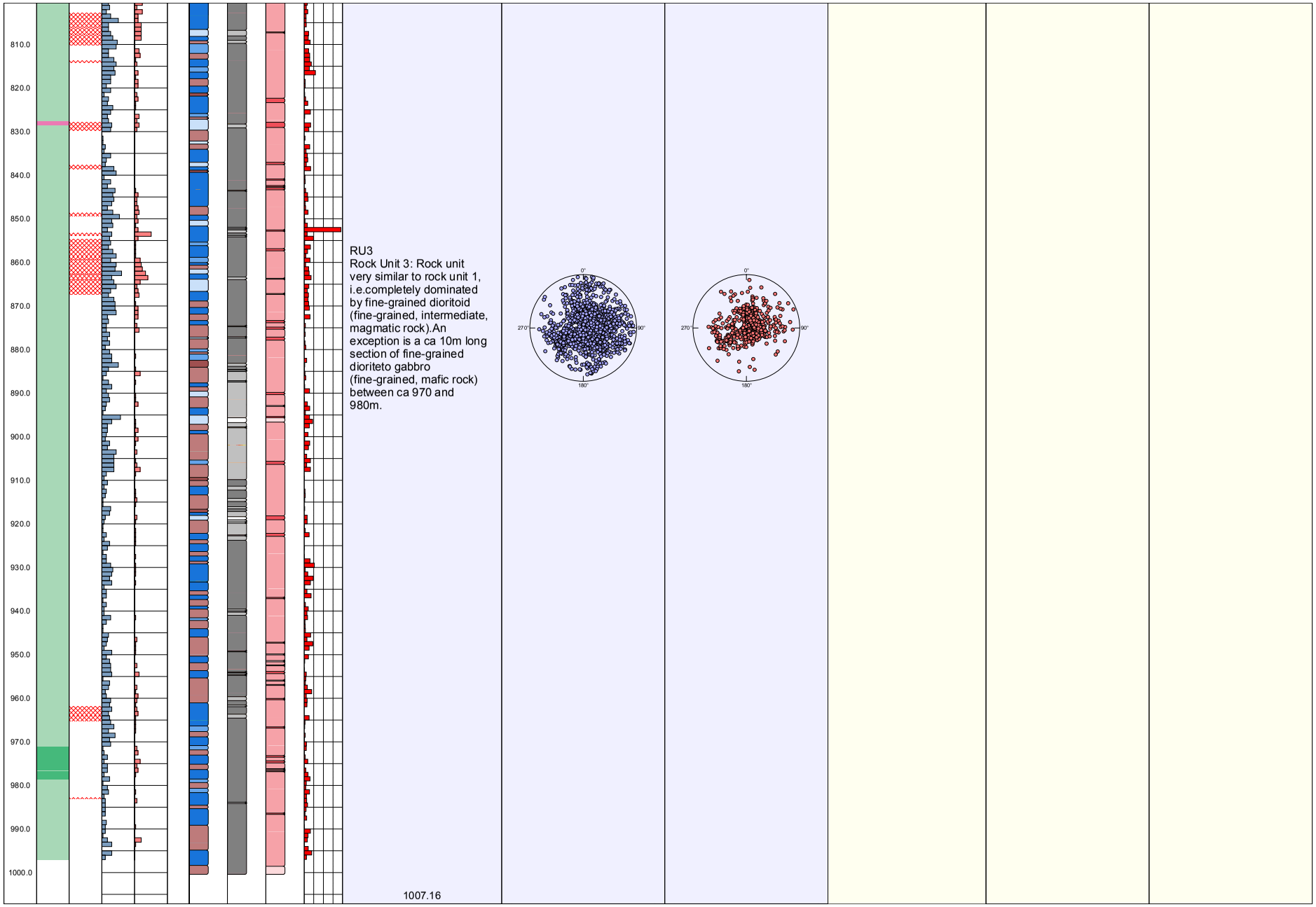
420.0
430.0
440.0
450.0
460.0
470.0
480.0
490.0
500.0
510.0
520.0
530.0
540.0
550.0
560.0
570.0
580.0
470.00
470.00
511.00
DZ2
Strong alteration indicated by low resistivity, low magnetic susceptibility and Boremap data.
Oriented radar reflectors occur at 519.4 m with the orientation 69/051 and at 523.8 m with the orientation 77/237.
532.00
0°
90°
180°
270°
0°
90°
180°
270°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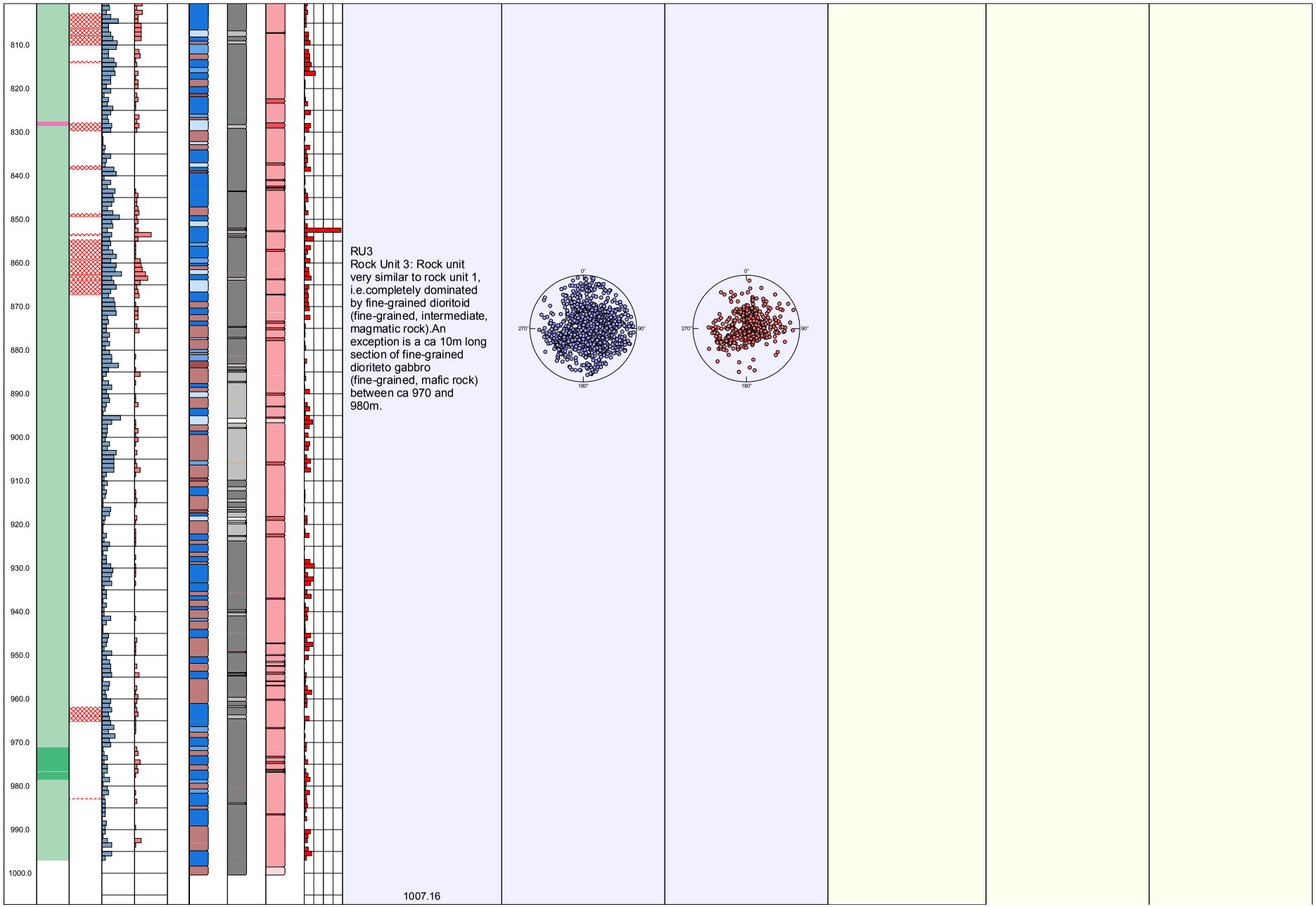
840.0
850.0
860.0
870.0
880.0
890.0
900.0
910.0
920.0
930.0
940.0
950.0
960.0
970.0
980.0
990.0
1000.0
RU3
Rock Unit 3: Rock unit very similar to rock unit 1, i.e.completely dominated by fine-grained dioritoid (fine-grained, intermediate, magmatic rock).An exception is a ca 10m long section of fine-grained dioriteto gabbro (fine-grained, mafic rock) between ca 970 and 980m.
0°
90°
180°
270°
1007.16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930.0
940.0
950.0
960.0
970.0
980.0
990.0
1000.0
RU3
Rock Unit 3: Rock unit very similar to rock unit 1, i.e.completely dominated by fine-grained dioritoid (fine-grained, intermediate, magmatic rock).An exception is a ca 10m long section of fine-grained dioriteto gabbro (fine-grained, mafic rock) between ca 970 and 980m.
0°
270°
90°
180°
0°
270°
90°
180°
1007.16

Geological single-hole interpretation for KAV01

Appendix 2

Title	SINGLE HOLE INTERPRETATION KAV01						
	Site	ÄVRÖ	**Inclination [°]**	-89.19	**Elevation [m.a.s.l.]**	14.03	**Signed data**
	Borehole	KAV01	**Date of mapping**	2004-03-22 12:53:00	**Drilling Start Date**	1977-04-21 00:00:00	
	Diameter [mm]	56	**Coordinate System**	RT90-RHB70	**Drilling Stop Date**	1986-11-16 00:00:00	
	Length [m]	757.310	**Northing [m]**	6367256.71	**Surveying Date**		
	Bearing [°]	225.61	**Easting [m]**	1553084.97	**Plot Date**	2006-04-02 21:14:58	

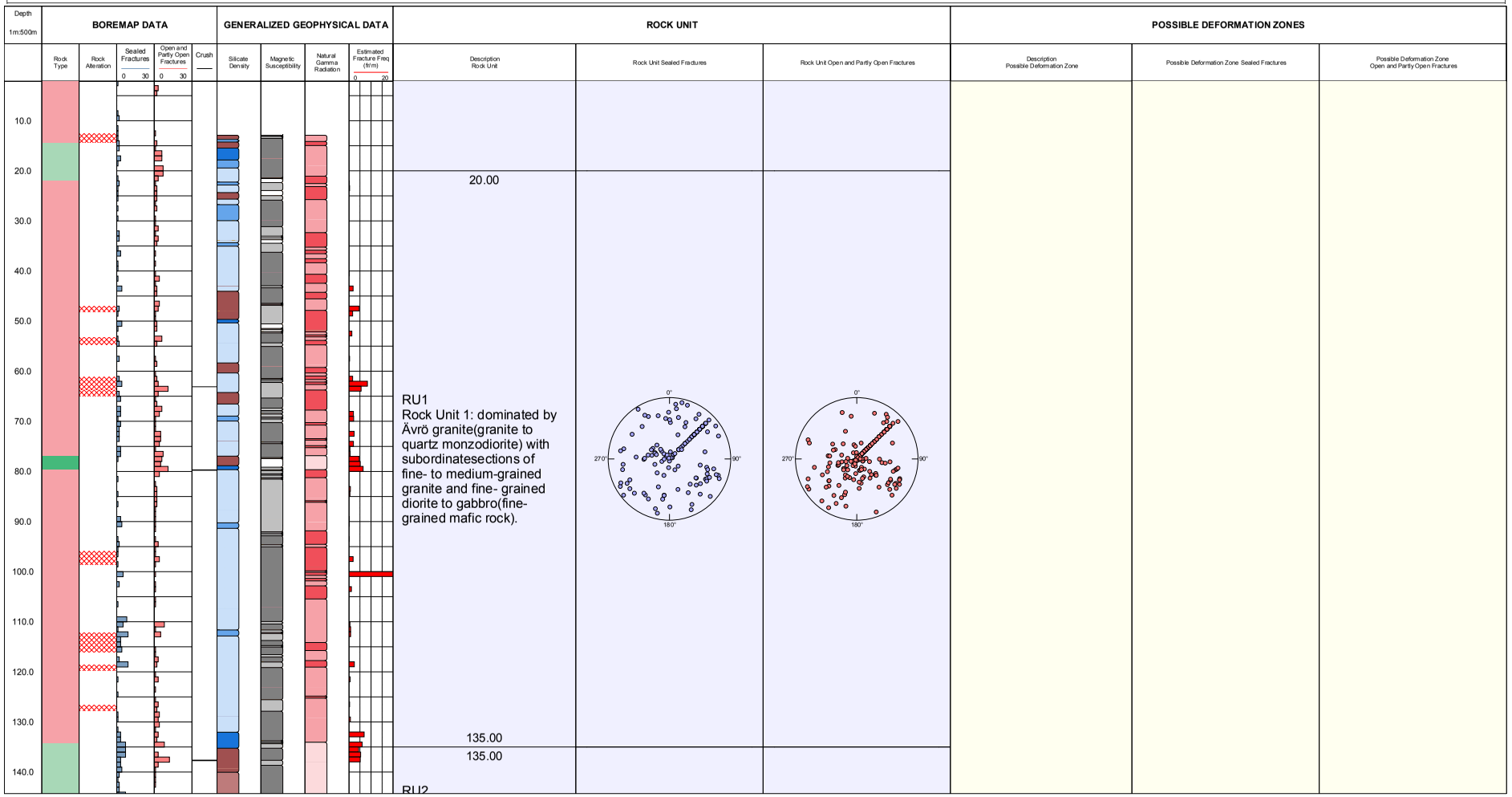
ROCKTYPE ÄVRÖ
- Fine-grained granite
- Granite
- Ävrö granite
- Fine-grained dioritoid
- Fine-grained diorite-gabbro

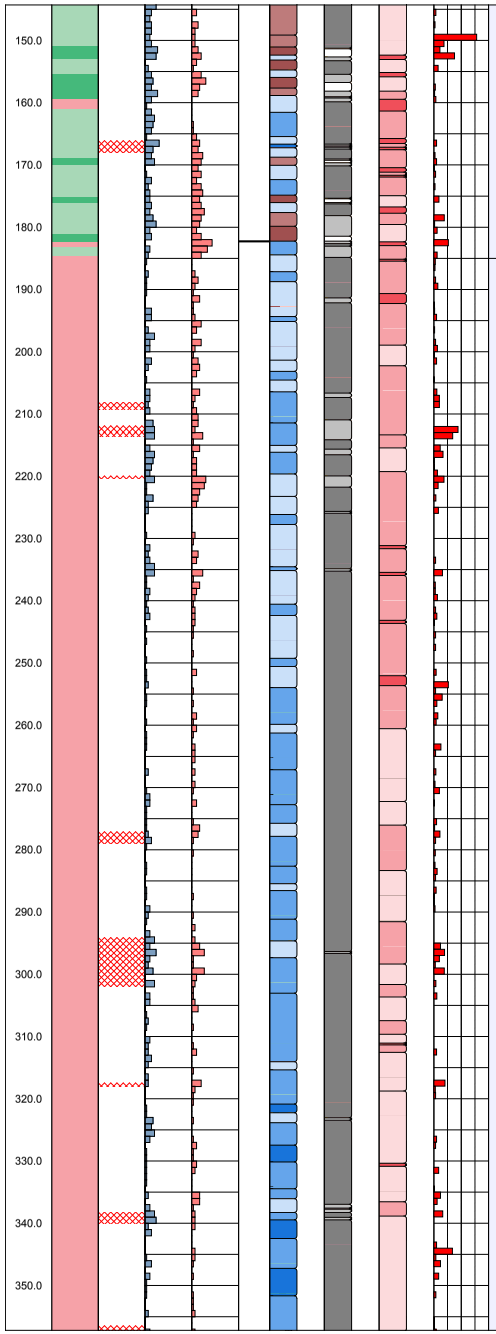
ROCK ALTERATION
- Oxidized

SILICATE DENSITY
- unclassified
- dens<2680 (Granite)
- 2680<dens<2730 (Granodiorite)
- 2730<dens<2800 (Tonalite)
- 2800<dens<2890 (Diorite)
- dens>2890 (Gabbro)

SUSCEPTIBILITET
- unclassified
- sus<0.001
- 0.001<sus<0.01
- 0.01<sus<0.1

NATURAL GAMMA
- unclassified
- gam<20
- 20<gam<30
- gam>30



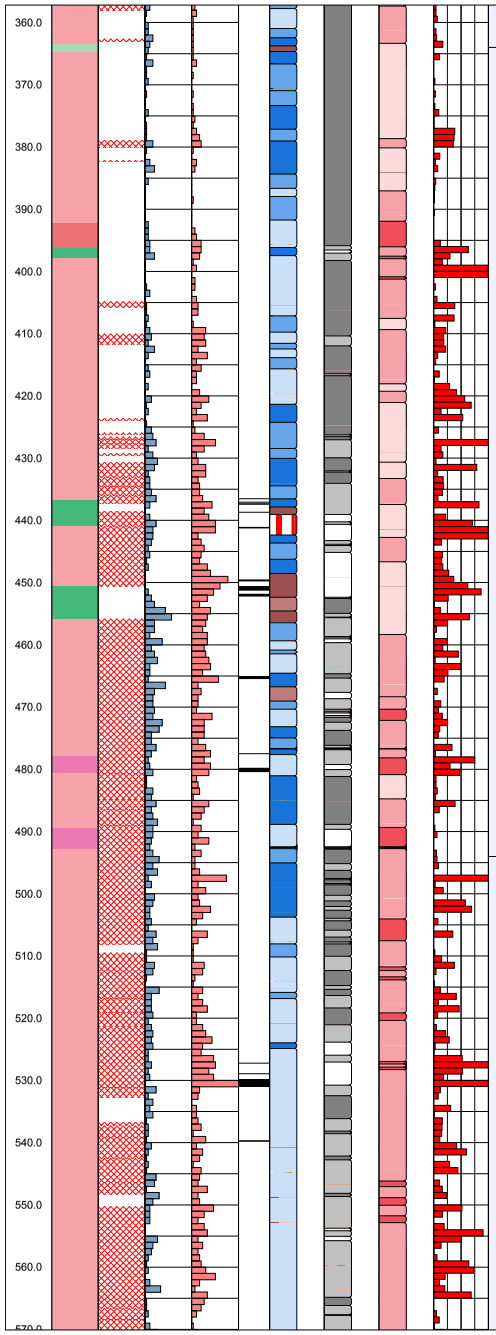


Rock Unit 2: dominated by fine-grained dioritoid(fine-grained, intermediate, magmatic rock),with < 4 m long sections of fine-grained dioriteto gabbro (fine-grained mafic rock) and subordinate sections of Ävrö granite (granite to quartz monzodiorite).

185.00

185.00

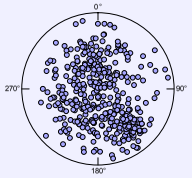
RU3
Rock Unit 3: Rock unit very similar to rock unit 1.Completely dominated by Ävrö granite (granite to quartz monzodiorite), with a few thin sectionsof fine- to medium-grained granite.

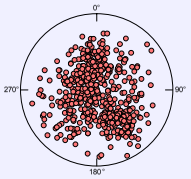


364.00

364.00

RU4
Rock Unit 4: Rock unit dominated by Ävrö granite(granite to quartz monzodiorite) with a few < 5 m longsections of fine- to medium-grained granite, fine-graineddiorite to gabbro (fine-grained mafic rock), medium- to coarse-grained granite and fine-grained dioritiod(fine-grained, intermediate, magmatic rock).

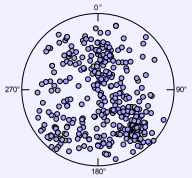


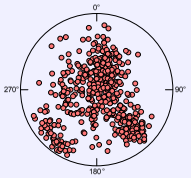


494.00

494.00

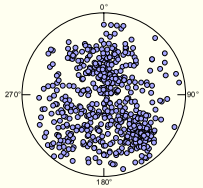
RU5
Rock Unit 5: very similar to rock unit 1 and 3. Completely dominated by Ävrö granite(granite to quartz monzodiorite).

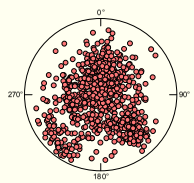




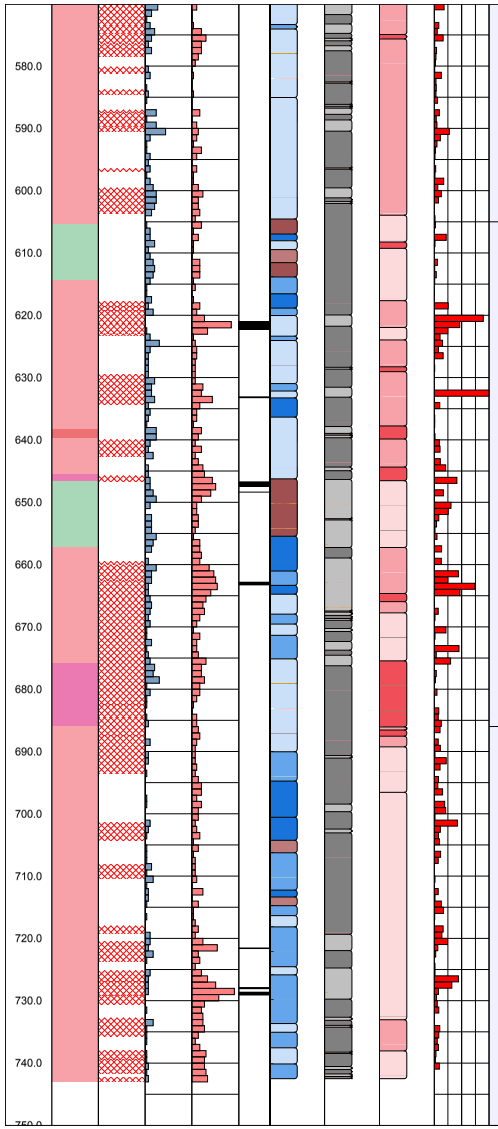
426.00

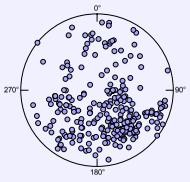
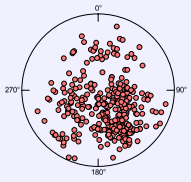
DZ1
The zone is characterized by increased fracturing and weak to medium alteration, indicated by low resistivity, low magnetic susceptibility and Boremap data. Increased fracturing in the interval 426-437.5 m. Alteration, low susceptibility and resistivity in the interval 437.5-464 m. Increased fracturing, low density and susceptibility in the interval 464-565 m. Medium to strong alteration is indicated in the section ca 431-464 m. The section ca 520-565 m seems to be heavily fractured. Eight oriented borehole radar reflectors occur within DZ1. At 438.6 m with the orientation 36/294, at 444.5 m with the orientation 35/273, at 447.3 m with the orientation 88/114, at 453.5 m with the orientation 37/087, at 479.7 m with the orientation 62/243, at 489.4 m with the orientation 44/078, at 532.2 m with the orientation 20/054 and at 554.0 m with the orientation 24/312.





565.00



605.00					
605.00 RU6 Rock Unit 6: Rock unit slightly dominated by Ävrö granite(granite to quartz monzodiorite) with up to 10 m long sectionof fine-grained dioritoid (fine-grained, intermediate, magmatic rock)and fine- to medium-grained granite and subordinate medium-tocoarse-grained granite. 686.00					
686.00 RU7 Rock Unit 7: Rock unit very similar to rock units 1, 3 and 5.Completely dominated by Ävrö granite (granite to quartz monzodiorite). 750.00