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Geoscientific Single Hole Interpretation (GSHI) of KFR90 and KFR91

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Abstract

This report presents the results from the geoscientific single hole interpretation (GSHI) of the core drilled boreholes KFR90 and KFR91.

Both of the boreholes were drilled in the SFR construction tunnel as a preparation for the excavation of the SFR facility.

The interpretation and identification of rock units (RU) and borehole deformation zones (BDZ) along the boreholes is based on the geological mapping of the cores and data from geophysical and hydrogeological measurements.

The number of rock units identified are 5 in KFR90 and 7 in KFR91. The number of borehole deformation zones identified are 5 in KFR90 and 4 in KFR91 with confidence levels varying from low (1) to high (3).

Sammanfattning

Denna rapport presenterar resultat från den geovetenskapliga enhålstolkningen (GSHI) av de kärnborrade borrhålen KFR90 och KFR91.

Båda hålen borrades i SFR:s byggtunnel inför utbyggnaden av SFR.

Tolkningen och identifieringen av bergenheter (RU) och borrhålsdeformationszoner (BDZ) längs borrhålen baseras på den geologiska karteringen av kärnorna samt data från geofysiska och hydrogeologiska undersökningar i borrhålen.

Antalet bergenheter identifierade är 5 respektive 7 i KFR90 och KFR91. Antalet borrhålsdeformationszoner identifierade är 5 i KFR90 och 4 i KFR 91, med en konfidens som varierar från låg (1) till hög (3).

Content

1 Introduction

Primary geological, geophysical and hydrogeological data stored in the SKB database SICADA need to be integrated and synthesized before they can be used for deterministic 3D geological modelling. The integrated synthesis is provided by the SKB method of geoscientific single hole interpretation (SKB MD 810.006), which aims to document all the rock units (RU) that exceed a minimum length of 5-10 m along the borehole, as well as the borehole deformation zones (BDZ) that are intersected by the borehole.

The identification of these geological features is carried out independently for each borehole, in connection with an analysis of base data and an inspection of the drill core. The end result of this procedure is an integrated series of different logs and accompanying descriptive documents.

This document reports the geological single hole interpretation of the cored boreholes KFR90 and KFR91 in the SFR construction tunnel. For borehole location within SFR see Figure 1-1.

This work was carried out in accordance with activity plan AP SFK-23-012 (in Swedish). The controlling documents related to this activity are listed in Table 1-1.

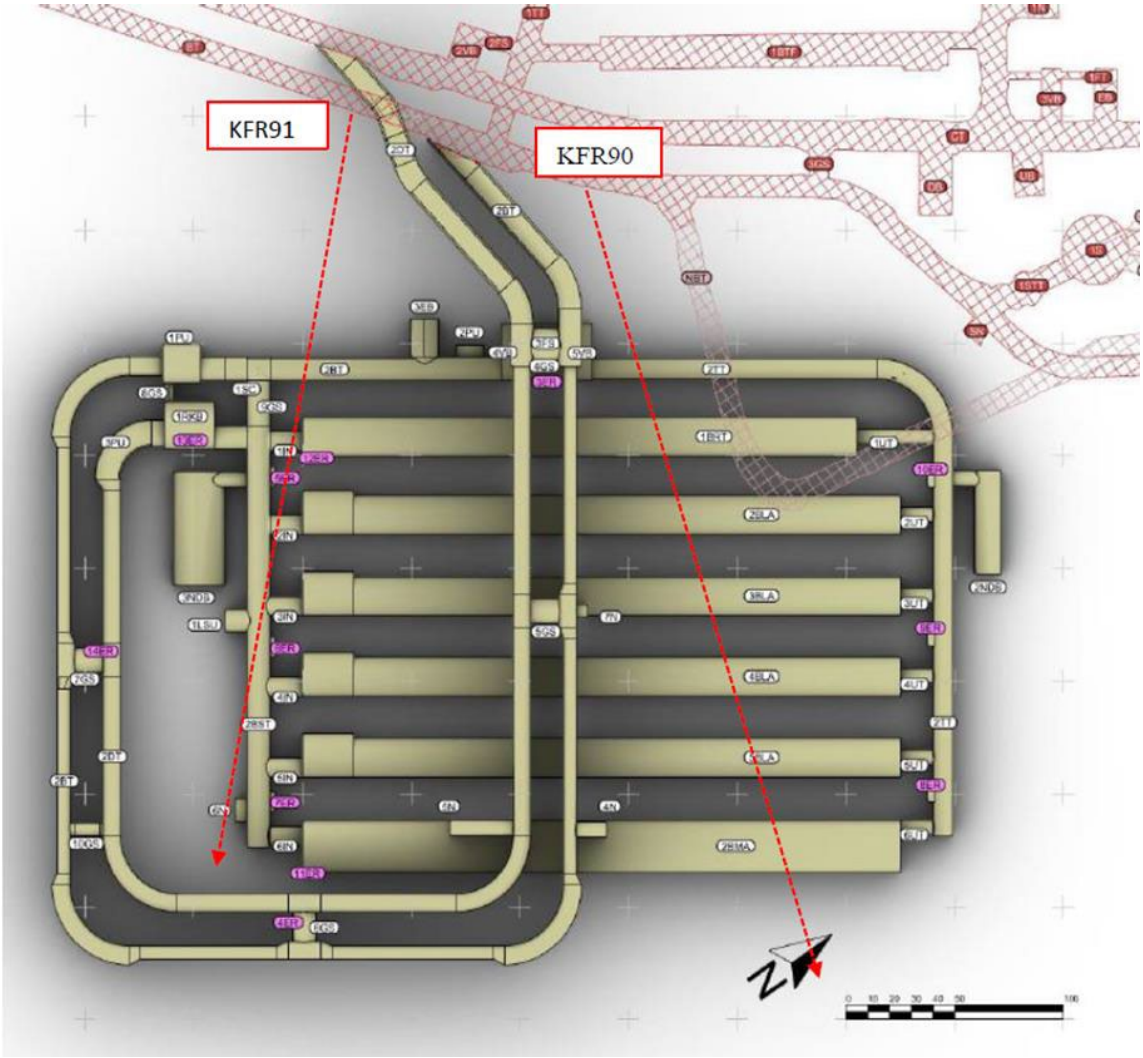


Figure 1-1. *The position of KFR90 and KFR 91 in SFR.*

Table 1-1 Controlling documents for this activity. Both the activity plan and the method description are SKBs internal controlling documents

Avtivity plan	Number	Version
Geovetenskaplig enhålstolkning (GSHI) av borrhål KFR90 och KFR91	AP SFK-23-012	1.0

Method descriptions	Number	Version
Metodbeskrivning för geovetenskaplig enhålstolkning	SKB MD 810.006	1.0

2 Objectives and scope

A geological single hole interpretation is carried out in order to merge sections of similar geological character into rock units (RU) and identify all borehole deformation zones (BDZ) within a borehole. The work involves an integrated interpretation of data from the geological borehole mapping and different geophysical and hydrogeological borehole logs. The end result is an integrated series of different logs and a brief description of the geological characteristics of each rock unit and borehole deformation zone.

The geological mapping of the cored borehole involves a documentation of the characteristics of the bedrock in the Boremap software, which combines drill core mapping with oriented imagery obtained by optical televiewer (OPTV) of the borehole wall.

Borehole logs used for the single hole interpretation are presented in a composite WellCAD plot. A more detailed description of the technique is provided in the method description for geoscientific single hole interpretation (SKB MD 810.006).

3 Data used for the geoscientific single hole interpretation (GSHI)

The material used as a basis for the geoscientific single hole interpretation was a WellCAD plot consisting of parameters obtained from the geological mapping and geophysical and hydrogeological measurements. The plot consists of several columns with multiple subordinate columns:

1. Depth (along the borehole)
2. Elevation (m.a.s.l.)
3. Rock type
    a. Type
    b. Occurrence
    c. Structure
    d. Texture
    e. Alteration
    f. Alteration intensity
    g. Structure orientation
4. Fault rock
    a. Fault rock
    b. Fault rock orientation
5. Fractures
    a. Open fractures
    b. Open total (open fractures + crush)
    c. Sealed fractures
    d. Sealed total (sealed fractures + sealed networks)
    e. Fractures total (all fractures)
    f. Open aperture (aperture of open fractures)
    g. Open width (width of open fractures)
    h. Sealed width (width of sealed fractures)
    i. Open, surface (orientation of open fractures and their surface roughness)
    j. Sealed orientation
    k. Crush
    l. Core loss
    m. RQD
    n. Sealed network
6. Geophysics
    a. Gamma
    b. Caliper
    c. Density
    d. Resistivity
    e. Magnetic susceptibility
    f. Sonic full
7. Hydrology
    a. PFL

For the full WellCAD plots used for the interpretation see Appendix 1 and Appendix 2.

4 Execution of the geoscientific single hole interpretation

The activity has been carried out by a multidisciplinary group consisting of geologists, hydrogeologists, geophysicists and rock mechanics, some of which also participated in the development of the source material. Over the course of two days the collected data was analysed along with inspection of the cores. Based on the group's collective knowledge and the SKB internal method description (SKB MD 810.006) the cores were divided into rock units and borehole deformation zones.

5 Results

5.1 KFR90

5.1.1 Rock units

Borehole	KFR90						
RU id	RU1a	RU2	RU3a	RU4	RU3b	RU1b	RU5
Sec_up	0	58	92	128	206	306	360
Sec_low	58	92	128	206	306	360	450,15
Rock Type 1	101061	101061	101061	101051	101061	101057	101057
Rock Type 2	101057	103076	101057	111058	111058	101061	101061
Rock Type 3	103076	101057	111058	101061	101051	102017	102017
Rock Type 4	102017	102017	-	-	101057	-	111058
Rock Type 5	-	-	-	-	-	-	-
Structure Type	Foliated	Foliated	Foliated	Foliated	Foliated	Foliated	Foliated
Structure Intensity	Medium	Faint	Weak	Faint	Faint	Medium	Medium
Est Open Fract Freq	Background level	Background level	Background level	Background level	Background level	Background level	Background level
Est Sealed Fract Freq	Slightly increased	Slightly increased	Background level	Slightly increased	Background level	Background level	Slightly increased
Alteration Type	Oxidation	Sericitization	Oxidation	Oxidation	Oxidation	Sericitization	Sericitization
Alteration Intensity	Weak	Faint	Medium	Faint	Faint	Faint	Medium
Confidence Level	High	High	High	High	High	High	High

The results are also visualized in a WellCAD plot in Appendix 3.

5.1.2 Borehole deformation zone

Borehole	KFR90				
BDZ id	BDZ01	BDZ02	BDZ03	BDZ04	BDZ05
Sec_up	17,5	108	159	177,5	309
Sec_low	33,5	112,5	173,5	193	317
Deformation Style	Brittle	Brittle	Brittle	Brittle	Brittle
Alteration Type 1	Oxidation	Oxidation	Oxidation	Oxidation	Oxidation
Alteration Intensity 1	Medium	Medium	Weak	Faint	Weak
Alteration Type 2	Argillization	Laumontization	Steatitization	-	Chloritization
Alteration Intensity 2	Medium	Medium	Weak	-	Medium
Alteration Type 3	Steatitization	-	Laumontization	-	Quartz dissolution
Alteration Intensity 3	Medium	-	Weak	-	Weak
Est Open Fract Freq	Increased	Slightly increased	Slightly increased	Background level	Increased
Est Sealed Fract Freq	Increased	Increased	Increased	Increased	Increased
Fracture Strike Set 1	NNW (325-355°)	NE (035-055°)	NNE (005-035°)	NW (305-325°)	NNW (325-355°)
Fracture Dip Set 1	Steeply dipping (70-90°)	Steeply dipping (70-90°)	Steeply dipping (70-90°)	Steeply dipping (70-90°)	Steeply dipping (70-90°)
Fracture Type Set 1	Open and sealed	Open and sealed	Open and sealed	Open and sealed	Open and sealed
Relative Intensity Set 1	70	100	80	60	60
Fracture Mineral Set 1: 1	Calcite	Calcite	Calcite	Laumontite	Calcite
Fracture Mineral Set 1: 2	Chlorite	Laumontite	Clay minerals	Calcite	Chlorite
Fracture Mineral Set 1: 3	Laumontite	-	Laumontite	-	Quartz
Fracture Surface Set 1	Smooth	Smooth	Smooth	Smooth	Smooth
Fracture Roughness Set 1	Undulating	-	Undulating	Undulating	Undulating
Fracture Strike Set 2	NE (035-055°)	-	NW (305-325°)	NE (035-055°)	NE (035-055°)
Fracture Dip Set 2	Steeply dipping (70-90°)	-	Steeply dipping (70-90°)	Steeply dipping (70-90°)	Steeply dipping (70-90°)
Fracture Type Set 2	Open and sealed	-	Open and sealed	Open and sealed	Open and sealed

Relative Intensity Set 2	30	-	20	30	40
Fracture Mineral Set 2: 1	Calcite	-	Laumontite	Laumontite	Calcite
Fracture Mineral Set 2: 2	Chlorite	-	Clay minerals	Calcite	Laumontite
Fracture Mineral Set 2: 3	Laumontite	-	Calcite	-	-
Fracture Surface Set 2	Smooth	-	Smooth	Smooth	Smooth
Fracture Roughness Set 2	Undulating	-	Undulating	Undulating	Undulating
Fracture Strike Set 3	-	-	-	SW (215-235°)	-
Fracture Dip Set 3	-	-	-	Gently dipping (0-45°)	-
Fracture Type Set 3	-	-	-	Open and sealed	-
Relative Intensity Set 3	-	-	-	10	-
Fracture Mineral Set 3: 1	-	-	-	Calcite	-
Fracture Mineral Set 3: 2	-	-	-	Clay minerals	-
Fracture Mineral Set 3: 3	-	-	-	-	-
Fracture Surface Set 3	-	-	-	-	-
Fracture Roughness Set 3	-	-	-	-	-
Fault Rock Type 1	Breccia	Breccia	Breccia	Breccia	Breccia
Fault Rock Type 2	Cataclasite	-	-	-	-
Rock Type 1	101057	111058	111058	101051	101057
Rock Type 2	101061	101061	101051	101061	102017
Focused Resistivity Anomaly	Strongly decreased	No significant change	Strongly decreased	Slightly decreased	Moderately decreased
P and S Wave Anomaly	Moderately decreased	No significant change	Slightly decreased	No significant change	Slightly decreased
Caliper Anomaly	Moderately increased	No significant change	No significant change	Slightly increased	No significant change
Fluid Temp Res Anomaly	-	-	-	-	-
Transmissivity Pfl	1,02E-08	3,28E-09	5,43E-09	2,03E-07	5,23E-08
Pumping Flow Rate	-	-	-	-	-
Transmissivity Pump Test	-	-	-	-	-

Confidence Level	High	Low	High	Medium	Medium
Core 1 Sec Up	27	-	-	-	-
Core 1 Sec Low	27,5	-	-	-	-
Core 2 Sec Up	30	-	-	-	-
Core 2 Sec Low	31	-	-	-	-
Core 3 Sec Up	-	-	-	-	-
Core 3 Sec Low	-	-	-	-	-
Comment	The focused resistivity decreased strongly around the zone cores. The caliper anomaly was in the form of occasional spikes.	All breccias belong to set 1	-	All breccias belong to fracture set 2. Lots of geophysical variation. The caliper anomaly was in the form of occasional spikes.	-

The results are also visualized in a WellCAD plot in Appendix 3.

5.2 KFR91

5.2.1 Rock units

Borehole	KFR91								
RU id	RU1	RU2	RU3	RU4	RU5a	RU6	RU5b	RU7	RU5c
Sec_up	0	40	54	123	180	208	248	280	300
Sec_low	40	54	123	180	208	248	280	300	340,11
Rock Type 1	101061	101061	101061	101061	101061	111058	101061	111058	101061
Rock Type 2	101057	103076	101051	101057	-	101061	101057	102017	-
Rock Type 3	-	-	-	102017	-	101057	111058	101057	-
Rock Type 4	-	-	-	-	-	-	-	101061	-
Rock Type 5	-	-	-	-	-	-	-	-	-
Structure Type	Foliated	Foliated	Foliated	Foliated	Foliated	Lineated	Foliated	Foliated	Foliated
Structure Intensity	Weak	Medium	Faint	Weak	Faint	Faint	Faint	Faint	Faint
Est Open Fract Freq	Background level	Background level	Background level	Background level	Background level	Slightly increased	Background level	Background level	Background level
Est Sealed Fract Freq	Background level	Background level	Slightly increased	Background level	Background level	Slightly increased	Background level	Background level	Background level
Alteration Type	Oxidation	-	-	Chloritization	-	Oxidation	-	Oxidation	Oxidation
Alteration Intensity	Medium	-	-	Weak	-	Medium	-	Weak	Weak
Confidence Level	High	High	High	High	High	High	High	High	High

The results are also visualized in a WellCAD plot in Appendix 4.

5.2.2 Borehole deformation zones

Borehole	KFR91			
BDZ id	BDZ01	BDZ02	BDZ03	BDZ04
Sec_up	6,5	131,5	223	322
Sec_low	12	147	237	335
Deformation Style	Brittle	Brittle	Brittle	Brittle
Alteration Type 1	-	Chloritization	Steatitization	Oxidation
Alteration Intensity 1	-	Weak	Weak	Weak
Alteration Type 2	-	Steatitization	Carbonatization	Laumontization
Alteration Intensity 2	-	Faint	Strong	Strong
Alteration Type 3	-	-	Laumontization	-
Alteration Intensity 3	-	-	Weak	-
Est Open Fract Freq	Slightly increased	Increased	Slightly increased	Background level
Est Sealed Fract Freq	Slightly increased	Increased	Increased	Increased
Fracture Strike Set 1	NE (035-055°)	E (085-095°)	NNW (325-355°)	W (265-275°)
Fracture Dip Set 1	Steeply dipping (70-90°)	Moderately dipping (70-90°)	Steeply dipping (70-90°)	Steeply dipping (70-90°)
Fracture Type Set 1	Open and sealed	Open and sealed	Open and sealed	Open and sealed
Relative Intensity Set 1	100	70	80	100
Fracture Mineral Set 1: 1	Calcite	Calcite	Calcite	Chlorite
Fracture Mineral Set 1: 2	Chlorite	Chlorite	Laumontite	Laumontite
Fracture Mineral Set 1: 3	-	Muscovite	-	-
Fracture Surface Set 1	Rough	Smooth	Rough	Smooth
Fracture Roughness Set 1	Undulating	Undulating	Undulating	Undulating
Fracture Strike Set 2	-	N (355-005°)	NE (035-055°)	-
Fracture Dip Set 2	-	Steeply dipping (70-90°)	Steeply dipping (70-90°)	-

Fracture Type Set 2	-	Open and sealed	Open and sealed	-
Relative Intensity Set 2	-	20	20	-
Fracture Mineral Set 2: 1	-	Calcite	Calcite	-
Fracture Mineral Set 2: 2	-	-	-	-
Fracture Mineral Set 2: 3	-	-	-	-
Fracture Surface Set 2	-	Rough	Rough	-
Fracture Roughness Set 2	-	Undulating	Planar	-
Fracture Strike Set 3	-	SW (215-235°)	-	-
Fracture Dip Set 3	-	Steeply dipping (70-90°)	-	-
Fracture Type Set 3	-	Open and sealed	-	-
Relative Intensity Set 3	-	10	-	-
Fracture Mineral Set 3: 1	-	Calcite	-	-
Fracture Mineral Set 3: 2	-	Laumontite	-	-
Fracture Mineral Set 3: 3	-	Clay minerals	-	-
Fracture Surface Set 3	-	Rough	-	-
Fracture Roughness Set 3	-	Undulating	-	-
Fault Rock Type 1	-	Breccia	Breccia	Breccia
Fault Rock Type 2	-	-	-	-
Rock Type 1	101057	101061	101061	101061
Rock Type 2	101061	102017	111058	
Focused Resistivity Anomaly	N/A	Moderately decreased	Strongly decreased	Moderately decreased
P and S Wave Anomaly	No significant change	Moderately decreased	Strongly decreased	Slightly decreased
Caliper Anomaly	Slightly increased	Slightly increased	Slightly increased	Slightly decreased
Transmissivity Pfl	5,07E-07	8,40E-07	3,17E-06	2,06E-08
Pumping Flow Rate	-	-	-	-

Transmissivity Pump Test	-	-	-	-
Confidence Level	Low	Medium	High	Medium
Core 1 Sec Up	-	-	229,9	-
Core 1 Sec Low	-	-	230,7	-
Core 2 Sec Up	-	-	-	-
Core 2 Sec Low	-	-	-	-
Core 3 Sec Up	-	-	-	-
Core 3 Sec Low	-	-	-	-
Comment	Fracture set 1 includes one crush. The focused resistivity measurements started below this section so no value has been recorded.	Hydraulically conductive	Hydraulically conductive. Fracture set 1 includes one crush and most of the breccias.	-

The results are also visualized in a WellCAD plot in Appendix 4.

References

SKBdoc documents will be submitted upon request to document@skb.se.

SKB MD 810.006 Metodbeskrivning för geovetenskaplig enhålstolkning (GSHI). SKBdoc 2002226 ver 1.0, Svensk Kärnbränslehantering AB. (In Swedish)

Appendix 1

Borehole ID: KFR90

Diameter (mm): 76

Length (m): 450.15

Bearing (°): 114

Inclination (°): -4

ROCK TYPE

- Amfibolite
- Pegmatite, pegmatitic granite
- Granite, granodiorite and tonalite, metamorphic
- Granite to granodiorite, metamorphic
- Felsic to intermediate volcanic rock, metamorphic
- Granite, fine- to medium-grained

ROCK ALTERATION

- Carbonatization
- Argillization
- Lamontization
- Chloritization
- Oxidation
- Sericitization
- Albitization
- Steatitization

ALTERATION INTENSITY

- Strong
- Medium
- Weak
- Faint

OPEN FRACTURE ORIENTATION/ALTERATION

- Rough
- Smooth
- Slickensided

ROCK OCCURRENCE

- Amfibolite
- Pegmatite, pegmatitic granite
- Granite, fine- to medium-grained
- Quartz-dominated hydrothermal vein/segregation
- Granite, granodiorite and tonalite, metamorphic
- Granite to granodiorite, metamorphic,

ROCK STRUCTURE

- Folieted
- Lineated

STRUCTURE ORIENTATION

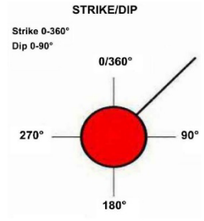
- Lineated
- Veined
- Foliated

SEALED ORIENTAION

- Sealed

STRIKE/DIP

Strike 0-360°
Dip 0-90°



FAULT ROCK

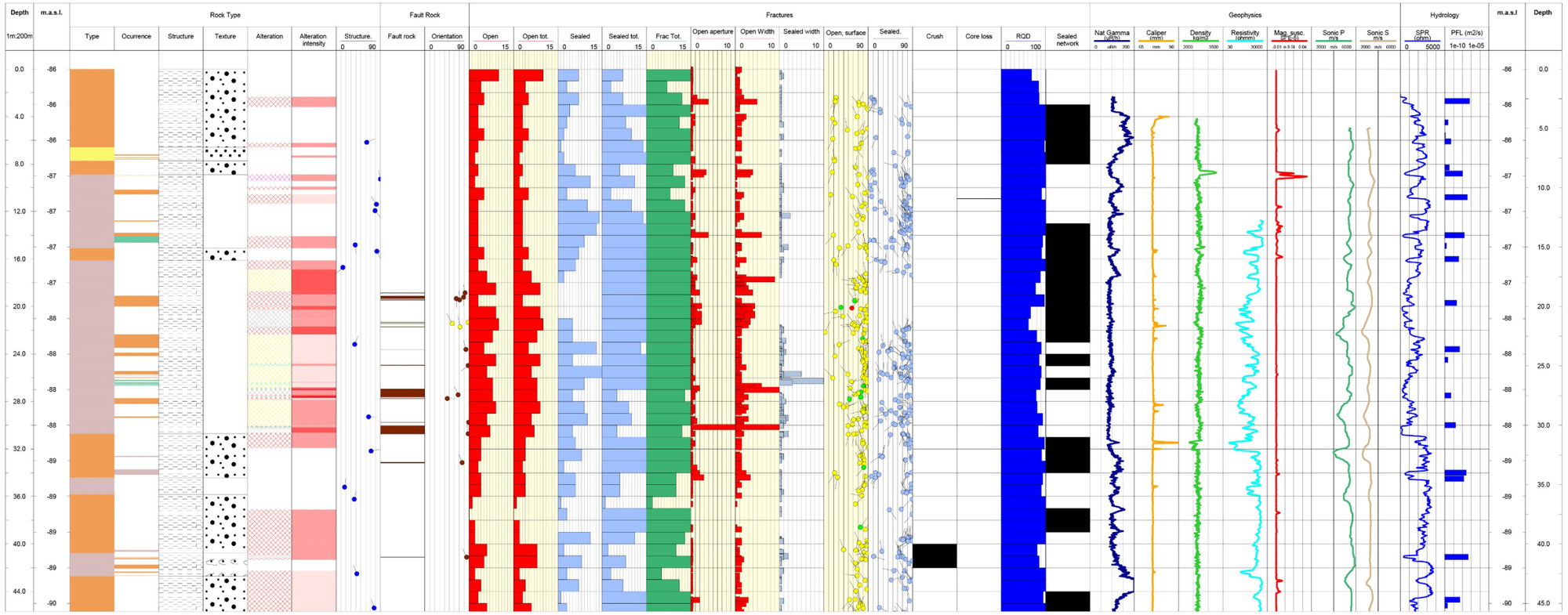
- Breccia
- Cataclasite

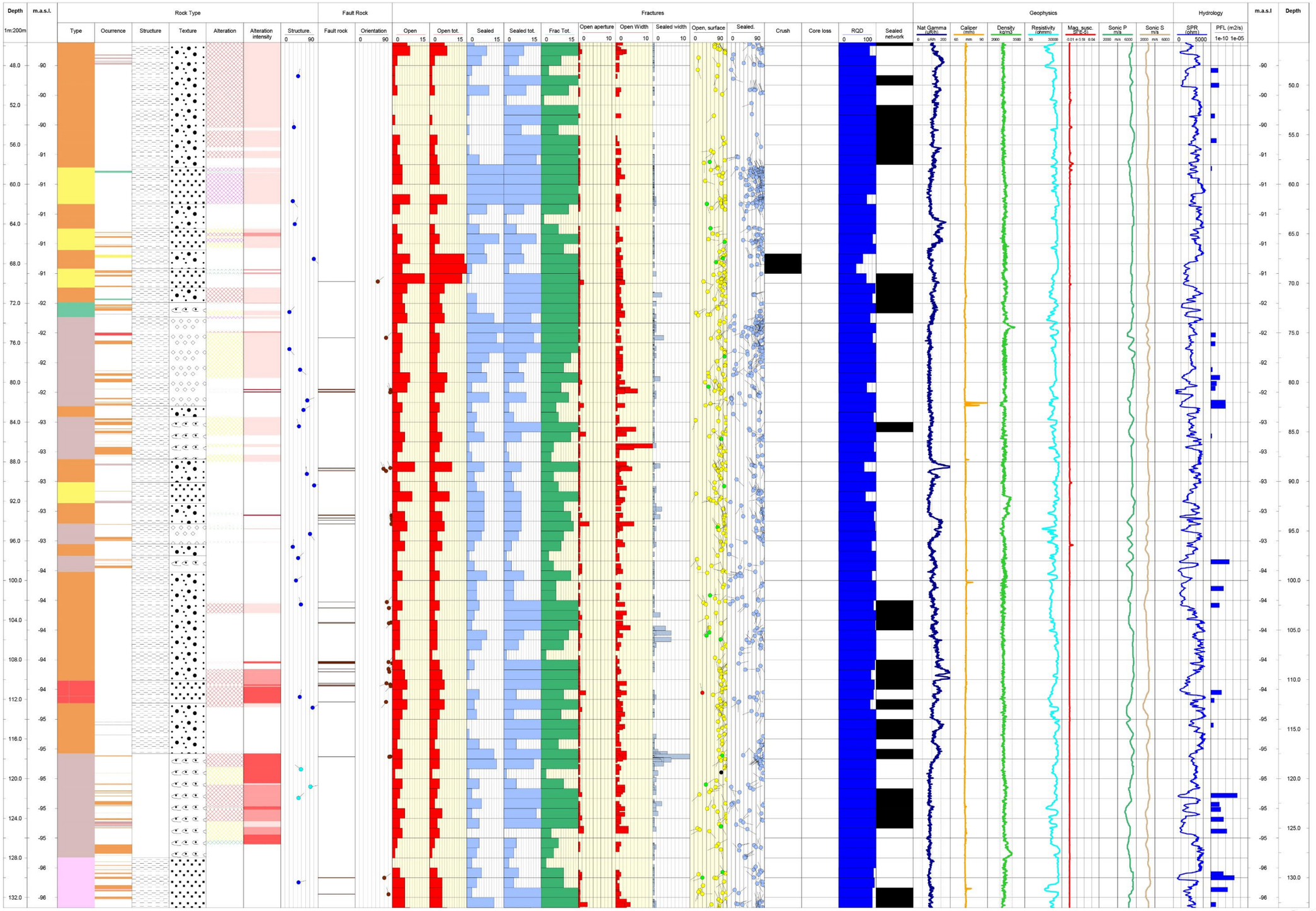
ROCK TEXTURE

- Equigranular
- Non-Equigranular
- Porphyritic
- Metamorphic

FAULT ROCK ORIENTATION

- Cataclasite
- Breccia

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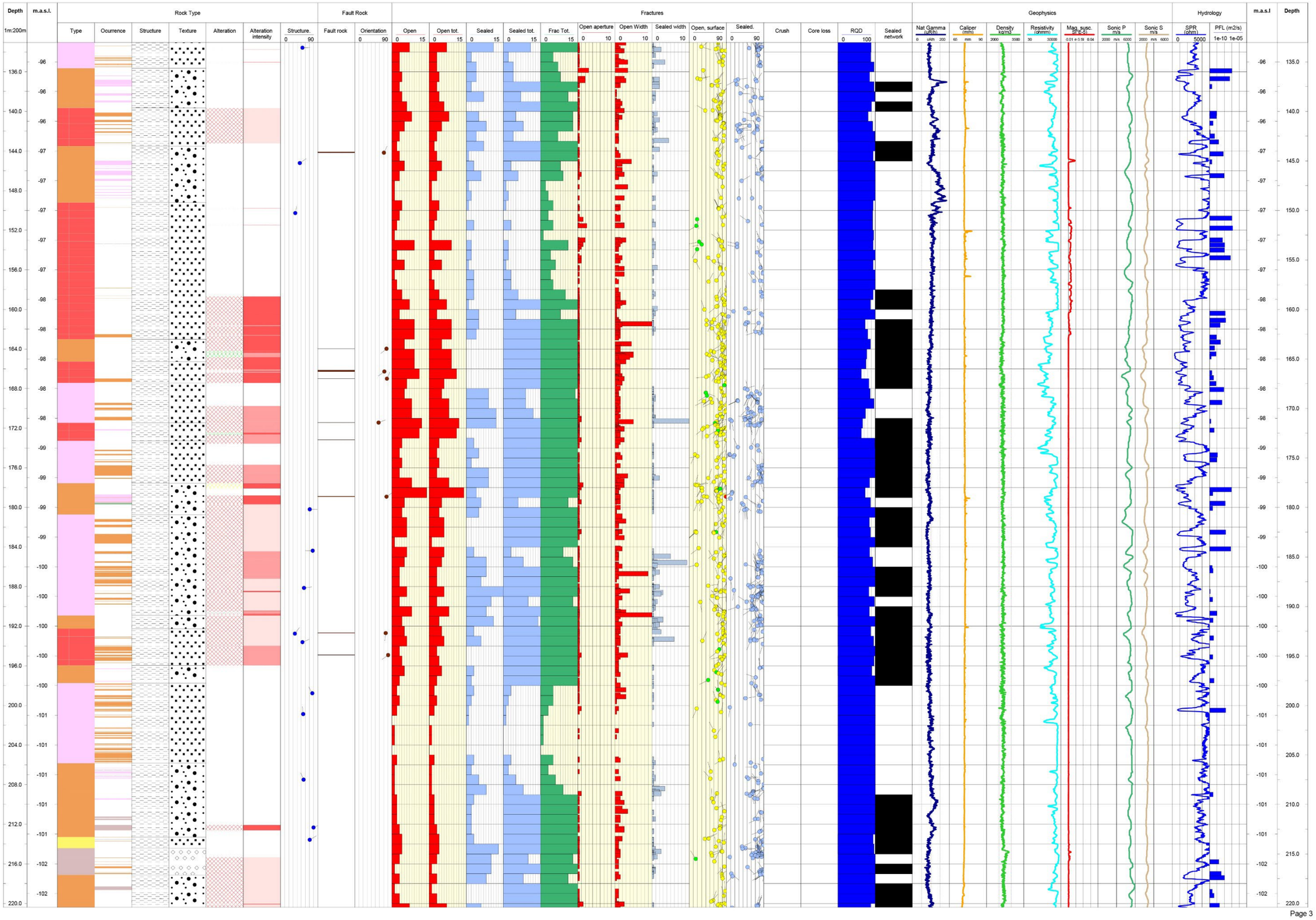
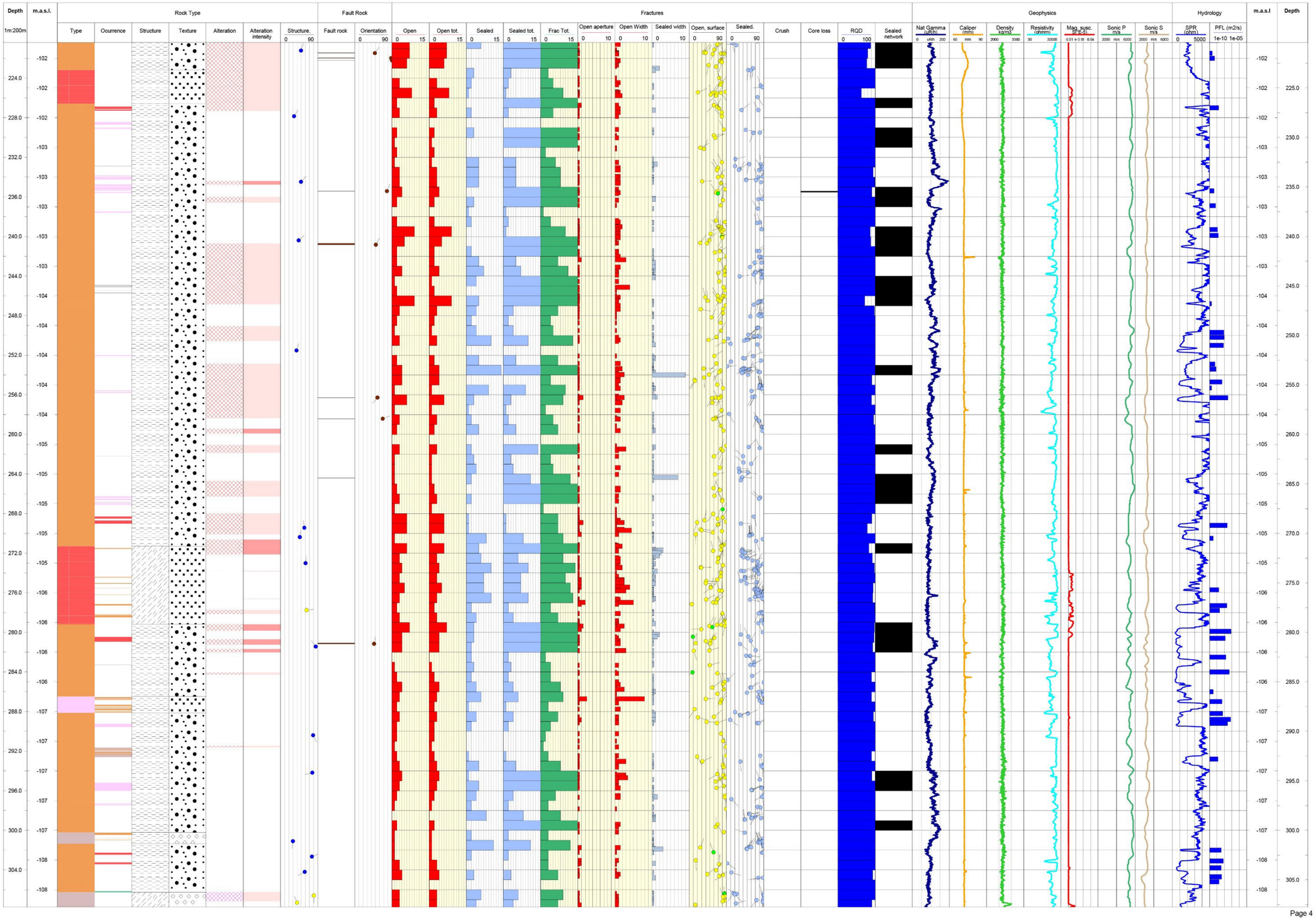
1m:200m
m.a.s.l.
Rock Type
Type
Ocurrence
Structure
Texture
Alteration
Alteration intensity
Structure.
Fault Rock
Fault rock
Orientation
Fractures
Open
Open tot.
Sealed
Sealed tot.
Frac Tot.
Open aperture
Open Width
Sealed width
Open, surface
Sealed.
Crush
Core loss
RQD
Sealed network
Geophysics
Nat Gamma (uR/h)
Caliper (mm)
Density kg/m3
Resistivity (ohmm)
Mag. susc. SI*E-3)
Sonic P m/s
Sonic S m/s
Hydrology
SPR (ohm)
PFL (m2/s)
m.a.s.l
Depth
Page 2


Depth
1m:200m
m.a.s.l.
Rock Type
Type
Ocurrence
Structure
Texture
Alteration
Alteration intensity
Structure.
Fault Rock
Fault rock
Orientation
Fractures
Open
Open tot.
Sealed
Sealed tot.
Frac Tot.
Open aperture
Open Width
Sealed width
Open, surface
Sealed.
Crush
Core loss
RQD
Sealed network
Geophysics
Nat Gamma (uR/h)
Caliper (mm)
Density kg/m3
Resistivity (ohmm)
Mag. susc. SI*E-3)
Sonic P m/s
Sonic S m/s
Hydrology
SPR (ohm)
PFL (m2/s)
m.a.s.l
Depth
Page 3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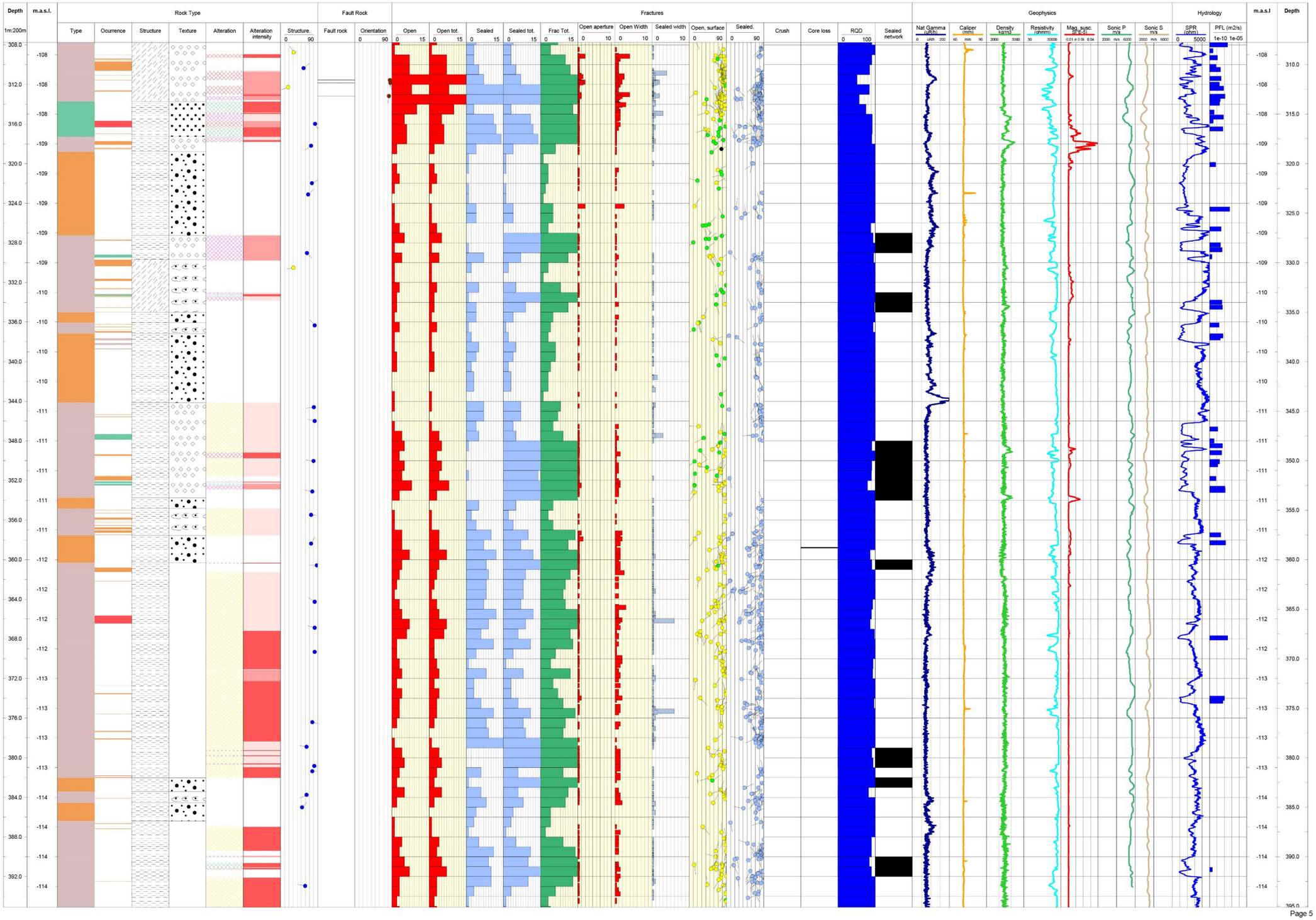
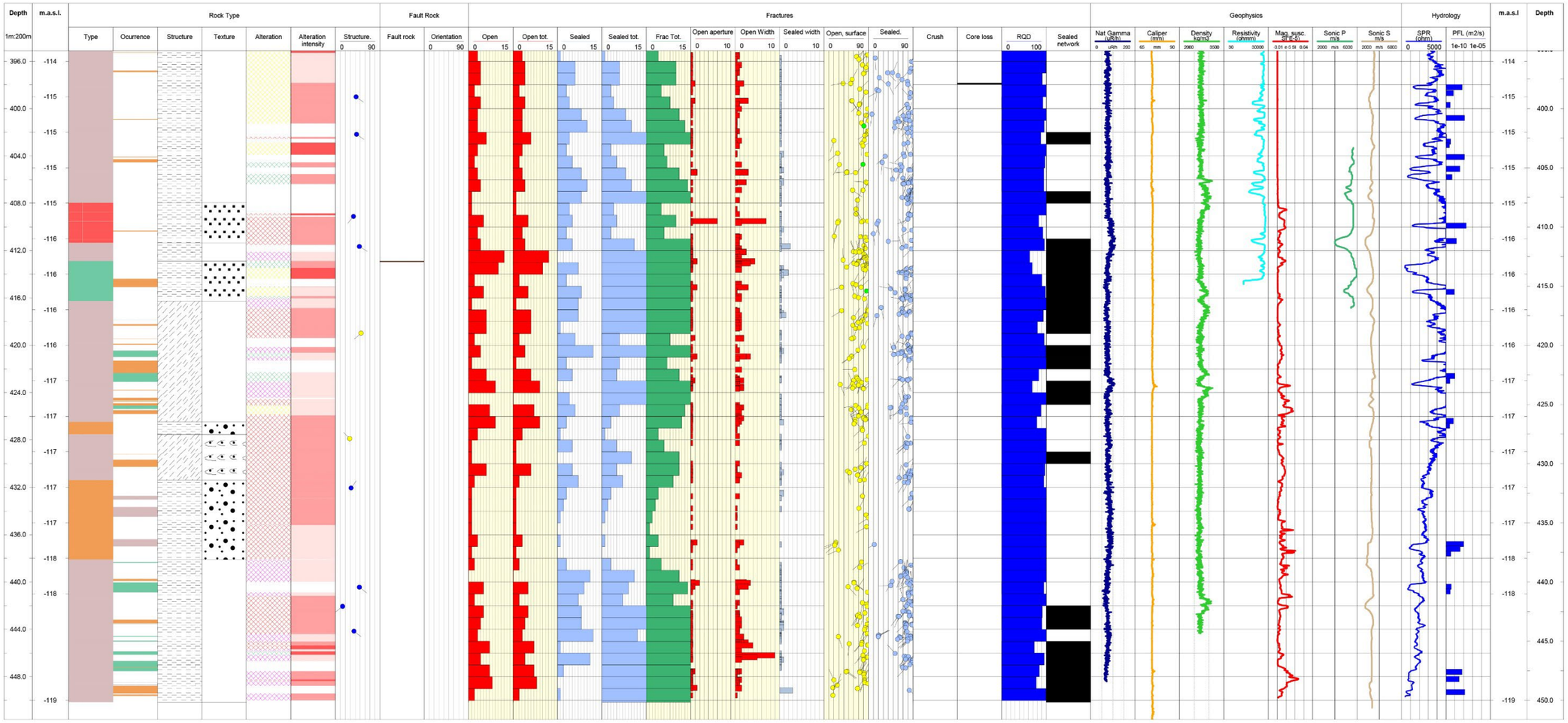
1m:200m
m.a.s.l.
Rock Type
Type
Ocurrence
Structure
Texture
Alteration
Alteration intensity
Structure.
Fault Rock
Fault rock
Orientation
Fractures
Open
Open tot.
Sealed
Sealed tot.
Frac Tot.
Open aperture
Open Width
Sealed width
Open, surface
Sealed.
Crush
Core loss
RQD
Sealed network
Geophysics
Nat Gamma (uR/h)
Caliper (mm)
Density kg/m3
Resistivity (ohmm)
Mag. susc. SI*E-3)
Sonic P m/s
Sonic S m/s
Hydrology
SPR (ohm)
PFL (m2/s)
m.a.s.l
Depth


Depth
1m:200m
m.a.s.l.
Rock Type
Type
Ocurrence
Structure
Texture
Alteration
Alteration intensity
Structure.
Fault Rock
Fault rock
Orientation
Fractures
Open
Open tot.
Sealed
Sealed tot.
Frac Tot.
Open aperture
Open Width
Sealed width
Open, surface
Sealed.
Crush
Core loss
RQD
Sealed network
Geophysics
Nat Gamma (uR/h)
Caliper (mm)
Density kg/m3
Resistivity (ohmm)
Mag. susc. SI*E-3)
Sonic P m/s
Sonic S m/s
Hydrology
SPR (ohm)
PFL (m2/s)
m.a.s.l
Depth
Page 5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Rock Type
Type
Ocurrence
Structure
Texture
Alteration
Alteration intensity
Structure.
0 90
Fault Rock
Fault rock
Orientation
0 90
Fractures
Open
Open tot.
Sealed
Sealed tot.
Frac Tot.
0 15
Open aperture
Open Width
Sealed width
0 10
Open, surface
Sealed.
0 90
Crush
Core loss
RQD
0 100
Sealed network
Geophysics
Nat Gamma (uR/h)
0 uR/h 200
Caliper (mm)
65 mm 90
Density kg/m3
2000 3500
Resistivity (ohmm)
30 30000
Mag. susc. SI*E-3)
0.01 e-3 SI 0.04
Sonic P m/s
2000 m/s 6000
Sonic S m/s
2000 m/s 6000
Hydrology
SPR (ohm)
0 5000
PFL (m2/s)
1e-10 1e-05
m.a.s.l
Depth
396.0
400.0
404.0
408.0
412.0
416.0
420.0
424.0
428.0
432.0
436.0
440.0
444.0
448.0
-114
-115
-116
-117
-118
-119
405.0
410.0
415.0
425.0
430.0
435.0
445.0
450.0

Appendix 2

Borehole ID: KFR91
Diameter (mm): 76
Length (m): 340.11
Bearing (°): 133
Inclination (°): -5

ROCK TYPE
- Amfibolite
- Pegmatite, pegmatitic granite
- Granite, granodiorite and tonalite, metamorphic
- Granite to granodiorite, metamorphic
- Felsic to intermediate volcanic rock, metamorphic
- Granite, fine- to medium-grained

ROCK ALTERATION
- Carbonatization
- Argillization
- Lamontization
- Chloritization
- Oxidation
- Sericitization
- Albitization
- Steatitization

ALTERATION INTENSITY
- Strong
- Medium
- Weak
- Faint

OPEN FRACTURE ORIENTATION/ALTERATION
- Rough
- Smooth
- Slickensided

ROCK OCCURRENCE
- Amfibolite
- Pegmatite, pegmatitic granite
- Granite, fine- to medium-grained
- Quartz-dominated hydrothermal vein/segregation
- Granite, granodiorite and tonalite, metamorphic
- Granite to granodiorite, metamorphic,

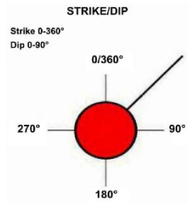
ROCK STRUCTURE
- Folieted
- Lineated

STRUCTURE ORIENTATION
- Foliated

SEALED ORIENTAION
- Sealed

STRIKE/DIP

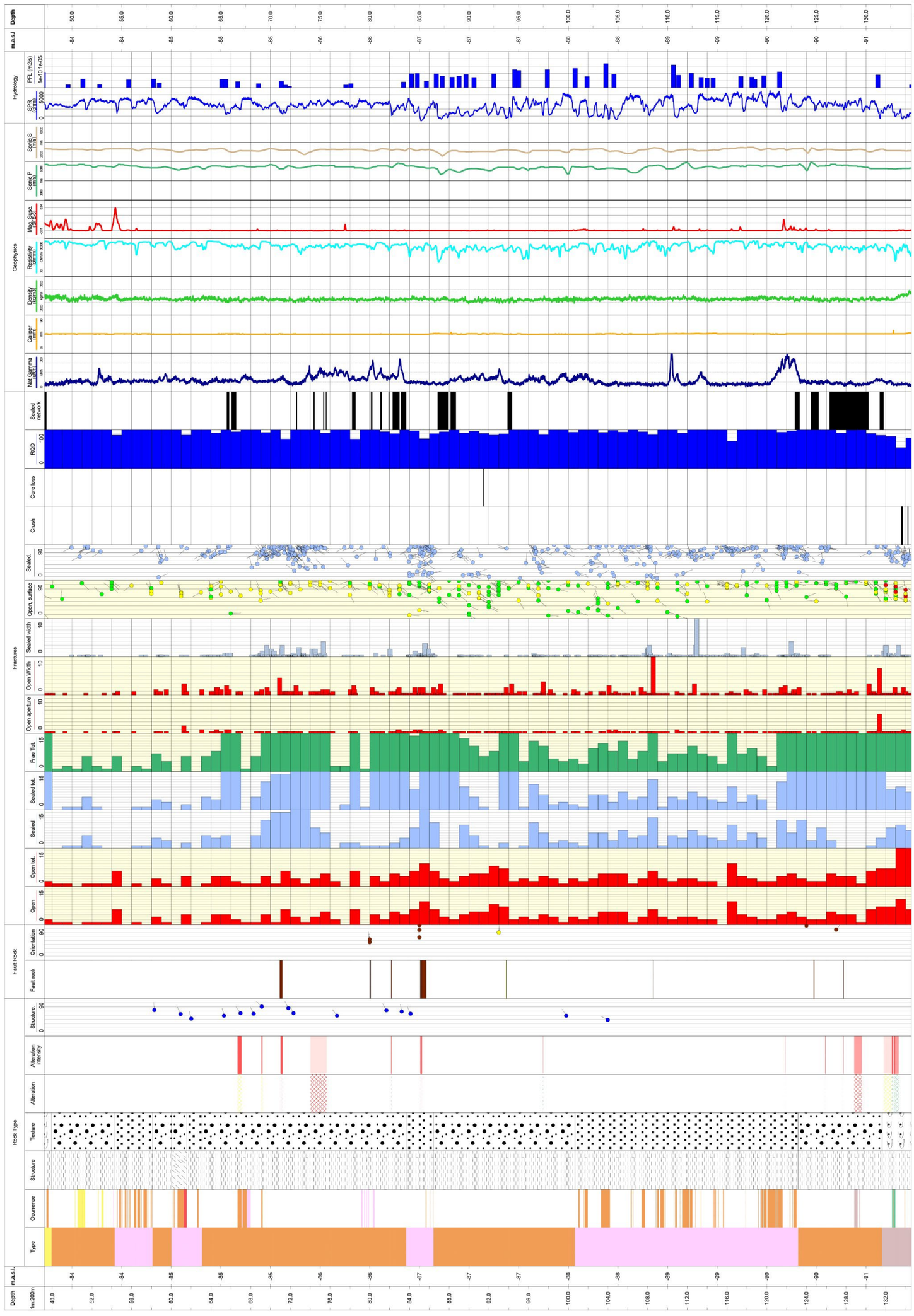
Strike 0-360°
Dip 0-90°

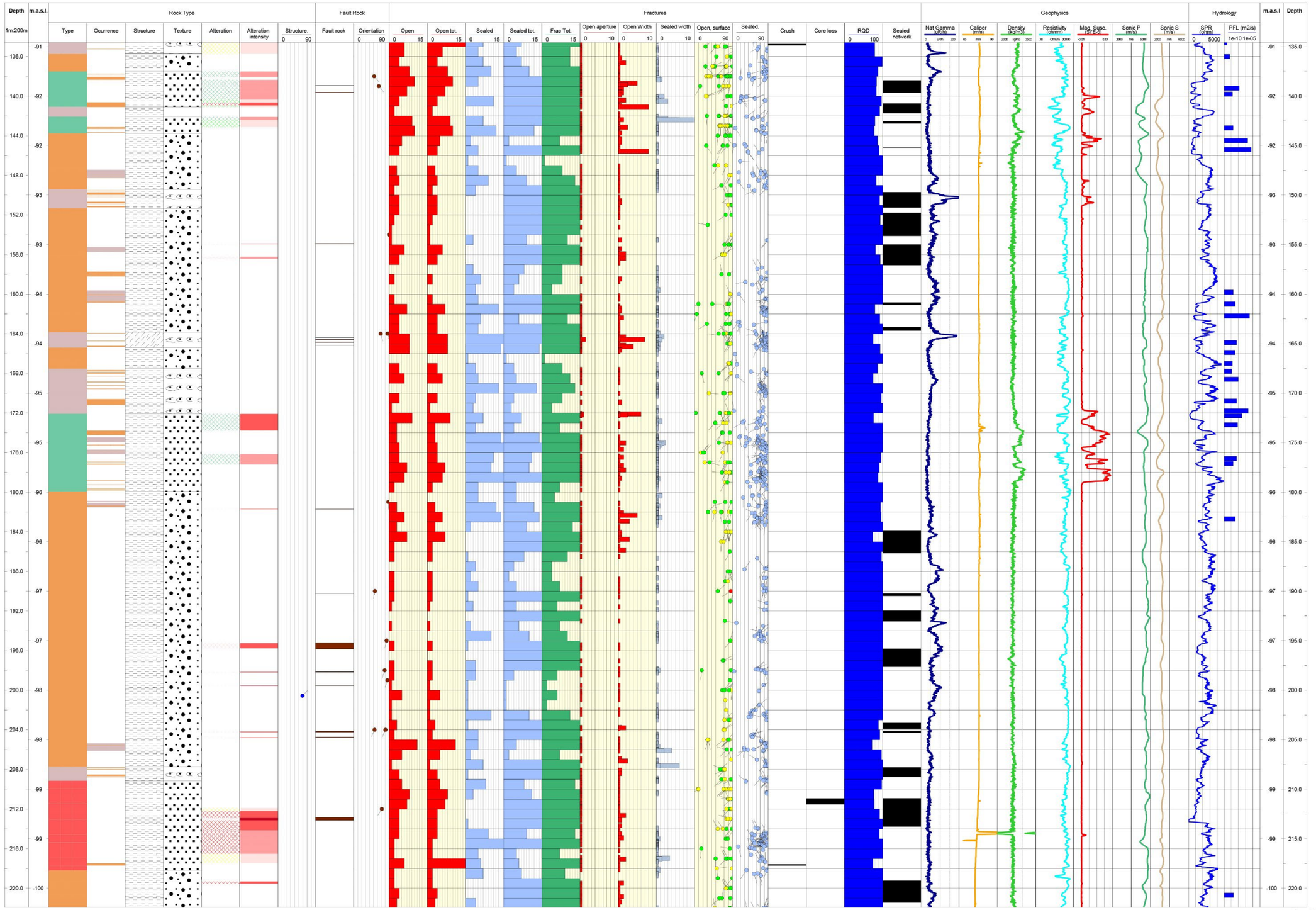


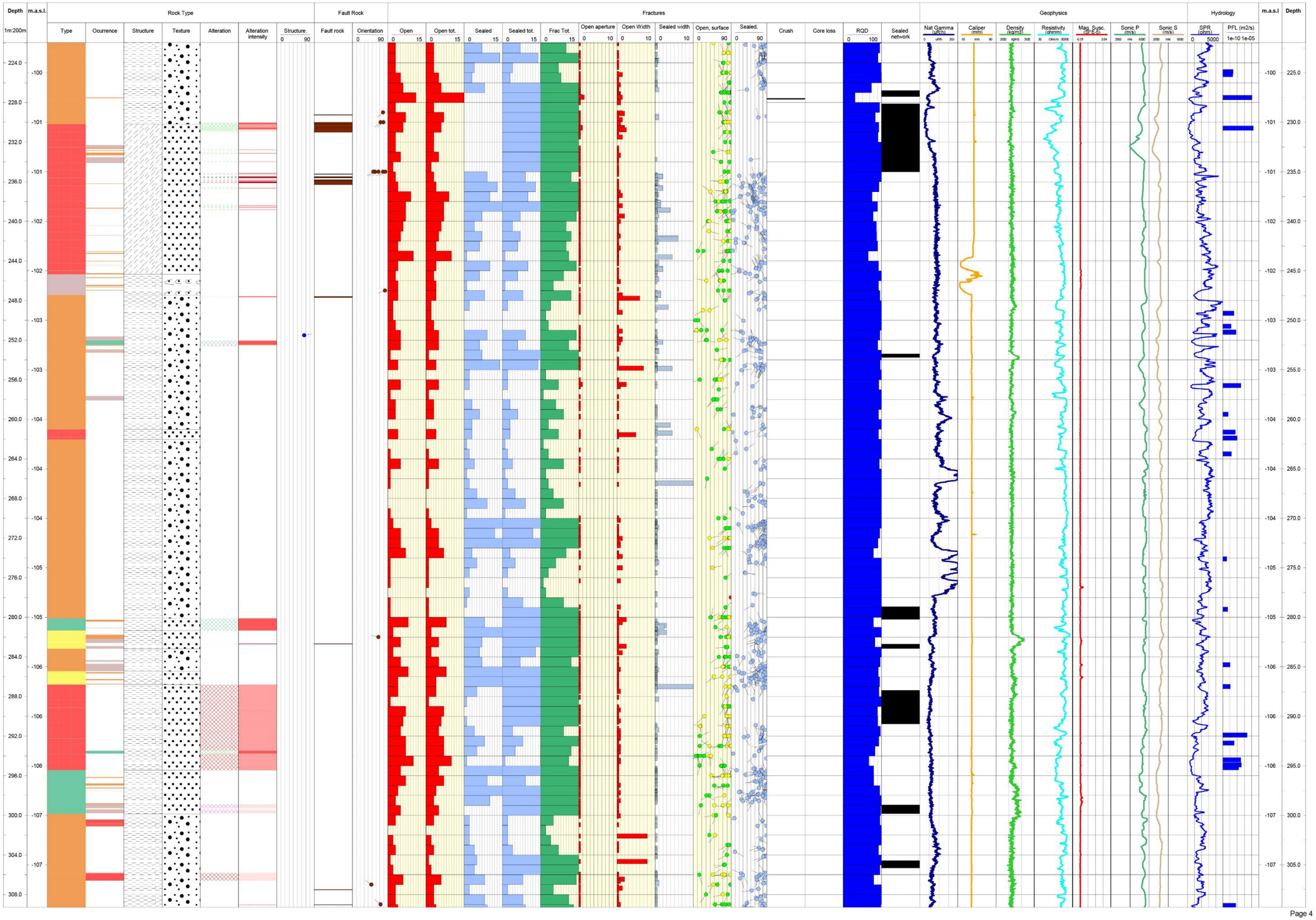
FAULT ROCK
- Breccia
- Cataclasite

ROCK TEXTURE
- Equigranular
- Non-Equigranular
- Metamorphic

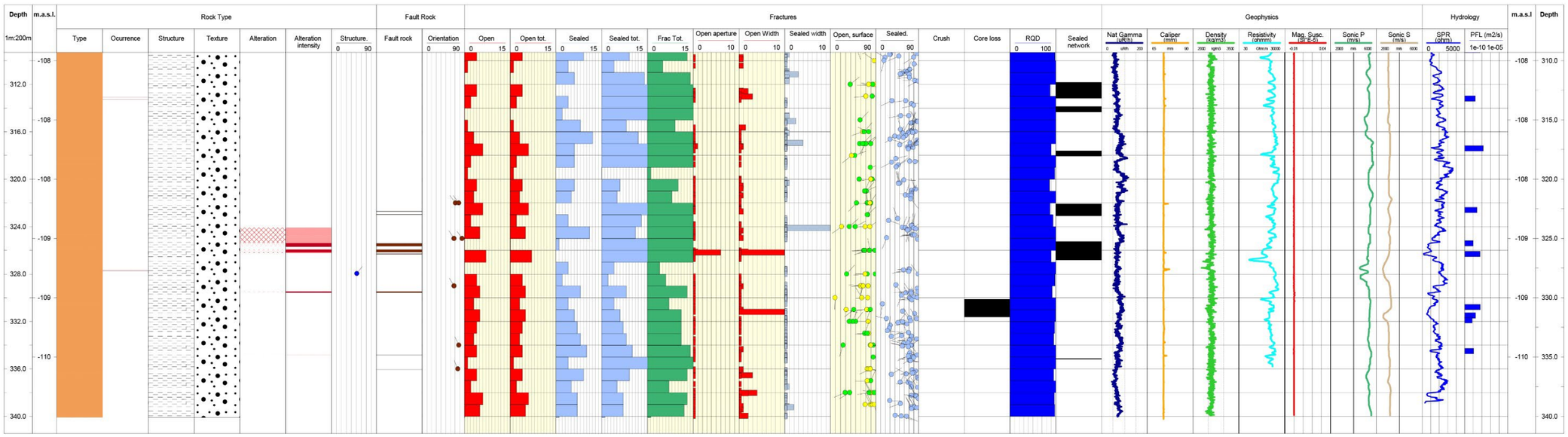
FAULT ROCK ORIENTATION
- Cataclasite
- Breccia


Depth
m.a.s.l.
Hydrology
PFL (m2/s)
SPR (ohm)
Geophysics
Sonic S (m/s)
Sonic P (m/s)
Mag. Susc. (SI E-3)
Resistivity (ohmm)
Density (kg/m3)
Caliper (mm)
Nat. Gamma (cps)
Sealed network
RQD
Core loss
Crush
Fractures
Sealed.
Open. surface
Sealed width
Open Width
Open aperture
Frac Tot.
Sealed tot.
Sealed
Open tot.
Open
Fault Rock
Orientation
Fault rock
Rock Type
Structure
Alteration intensity
Alteration
Texture
Structure
Ocurrence
Type
1m:200m


Depth
1m:200m
m.a.s.l.
Rock Type
Type
Ocurrence
Structure
Texture
Alteration
Alteration intensity
Structure.
Fault Rock
Fault rock
Orientation
Fractures
Open
Open tot.
Sealed
Sealed tot.
Frac Tot.
Open aperture
Open Width
Sealed width
Open, surface
Sealed.
Crush
Core loss
RQD
Sealed network
Geophysics
Nat Gamma (uR/h)
Caliper (mm)
Density (kg/m3)
Resistivity (ohmm)
Mag. Susc. (SI-E-5)
Sonic P (m/s)
Sonic S (m/s)
Hydrology
SPR (ohm)
PFL (m2/s)
1e-10 1e-05
m.a.s.l
Depth
Page 3


Depth
1m:200m
m.a.s.l.
Rock Type
Type
Ocurrence
Structure
Texture
Alteration
Alteration intensity
Structure.
0 90
Fault Rock
Fault rock
Orientation
0 90
Fractures
Open
Open tot.
Sealed
Sealed tot.
Frac Tot.
0 15
Open aperture
Open Width
Sealed width
0 10
Open, surface
Sealed.
0 90
Crush
Core loss
RQD
0 100
Sealed network
Geophysics
Nat Gamma (uR/h)
Caliper (mm)
Density (kg/m3)
Resistivity (ohmm)
Mag. Susc. (SI-E-5)
Sonic P (m/s)
Sonic S (m/s)
Hydrology
SPR (ohm)
0 5000
PFL (m2/s)
1e-10 1e-05
m.a.s.l
Depth
224.0 -100 225.0
228.0 -101 230.0
232.0 -101 235.0
236.0 -101 240.0
240.0 -102 245.0
244.0 -102 250.0
248.0 -103 255.0
252.0 -103 260.0
256.0 -104 265.0
260.0 -104 270.0
264.0 -104 275.0
268.0 -104 280.0
272.0 -105 285.0
276.0 -105 290.0
280.0 -105 295.0
284.0 -106 300.0
288.0 -106 305.0
292.0 -106
296.0 -107
300.0 -107
304.0 -107
308.0

Page 4


Depth
1m:200m
m.a.s.l.
Rock Type
Type
Ocurrence
Structure
Texture
Alteration
Alteration intensity
Structure.
0 90
Fault Rock
Fault rock
Orientation
0 90
Fractures
Open
Open tot.
Sealed
Sealed tot.
Frac Tot.
Open aperture
Open Width
Sealed width
Open, surface
Sealed.
0 15
0 10
0 90
Crush
Core loss
RQD
0 100
Sealed network
Geophysics
Nat Gamma (uR/h)
Caliper (mm)
Density (kg/m3)
Resistivity (ohmm)
Mag. Susc. (SI-E-5)
Sonic P (m/s)
Sonic S (m/s)
Hydrology
SPR (ohm)
0 5000
PFL (m2/s)
1e-10 1e-05
m.a.s.l
Depth
-108
-109
-110
312.0
316.0
320.0
324.0
328.0
332.0
336.0
340.0
310.0
315.0
325.0
330.0
335.0

Appendix 3

Borehole ID: KFR90

Diameter (mm): 76

Length (m): 450.15

Bearing (°): 114

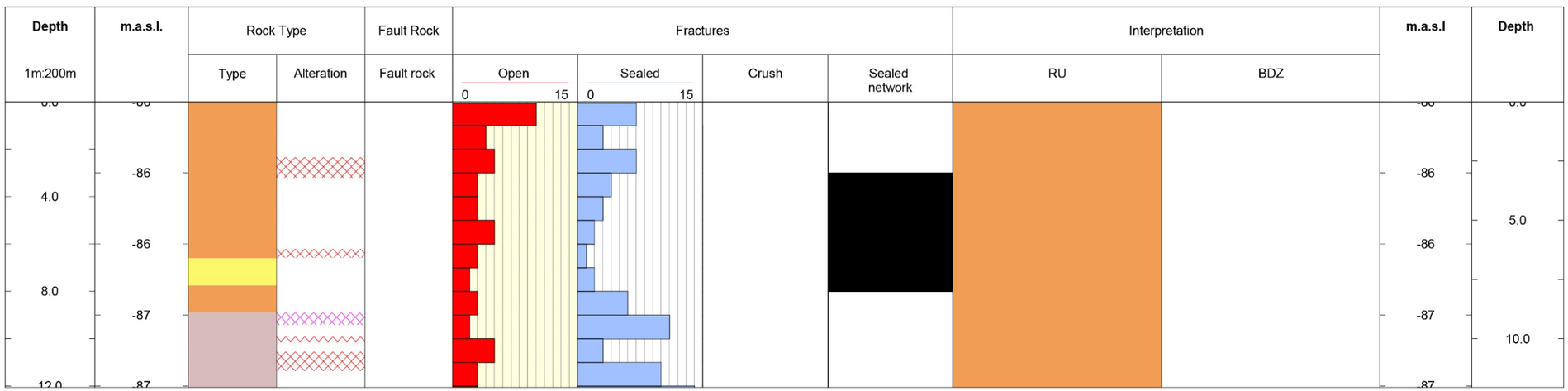
Inclination (°): -4

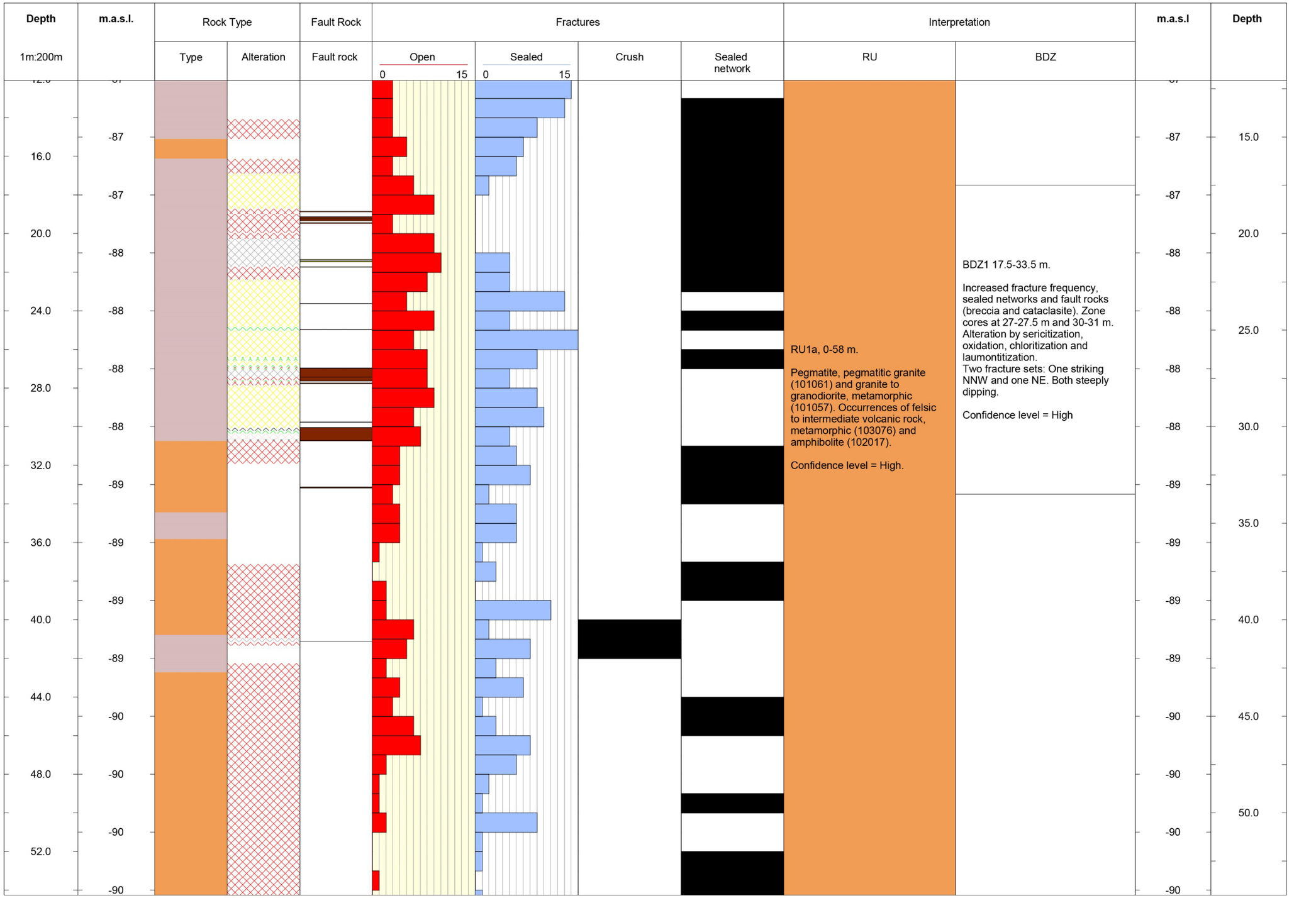
ROCK TYPE

- Amfibolite
- Pegmatite, pegmatitic granite
- Granite, granodiorite and tonalite, metamorphic
- Granite to granodiorite, metamorphic
- Felsic to intermediate volcanic rock, metamorphic
- Granite, fine- to medium-grained

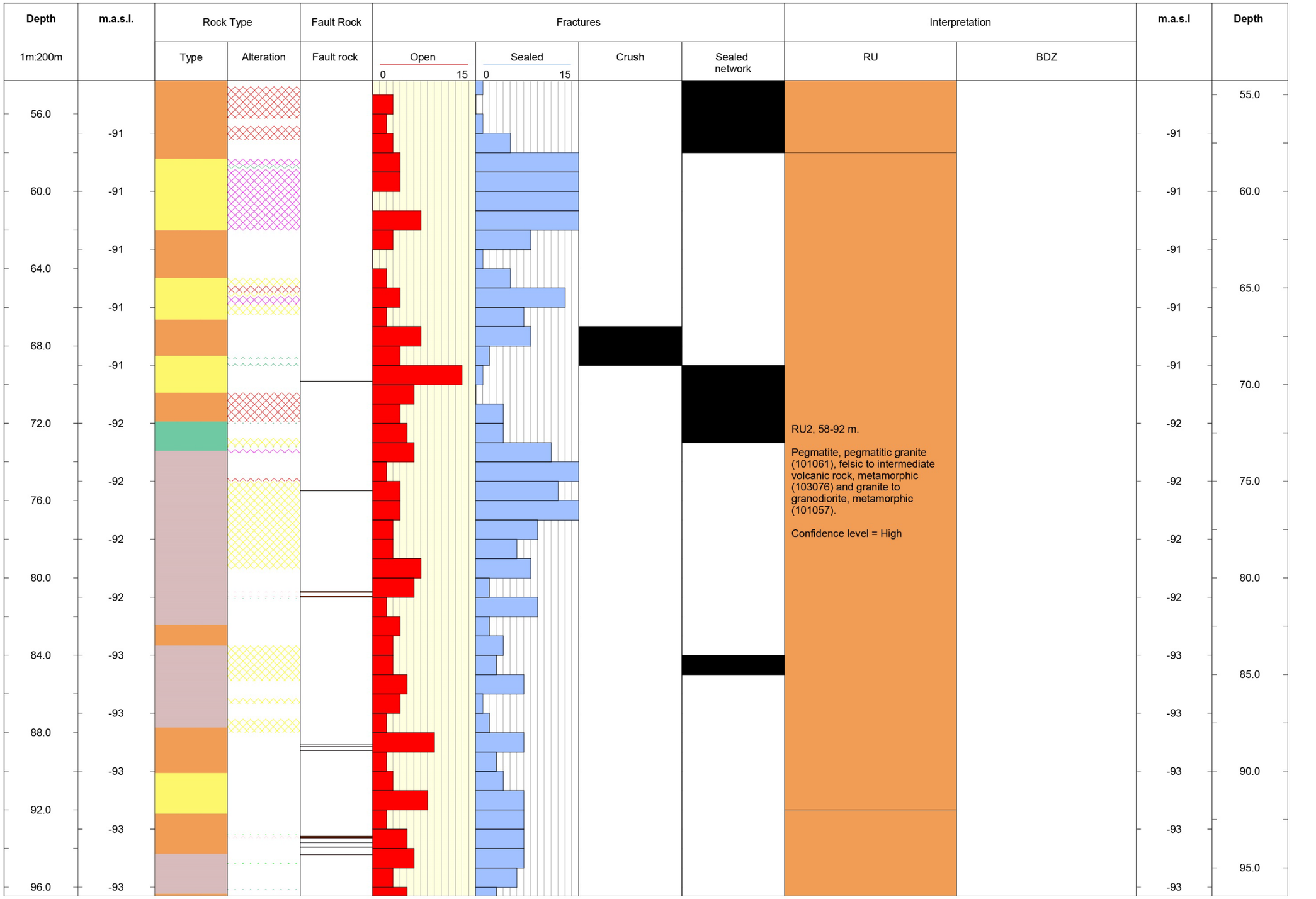
ROCK ALTERATION

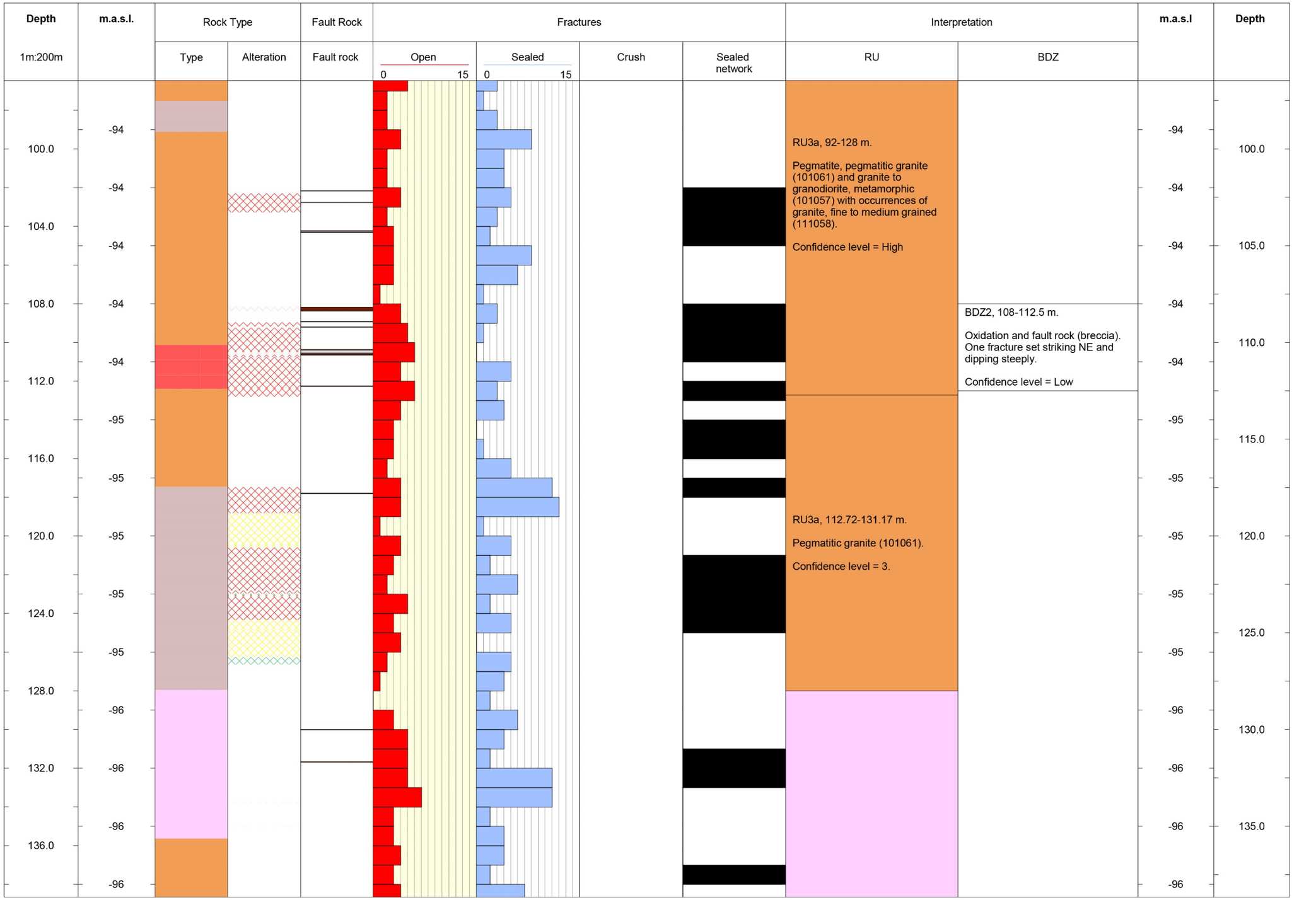
- Carbonatization
- Argillization
- Lamontization
- Chloritization
- Oxidation
- Sericitization
- Albitization
- Steatitization



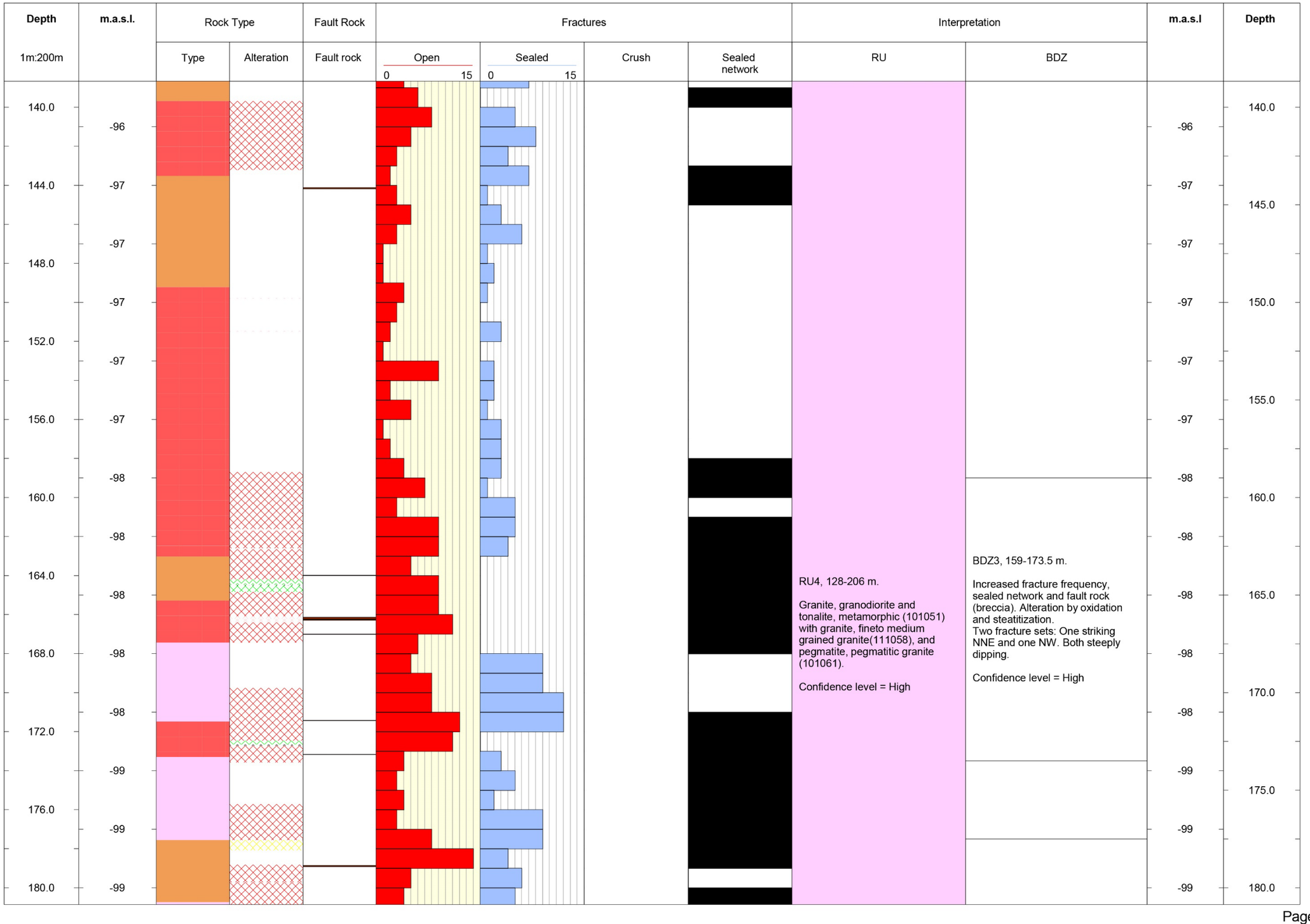

Depth
1m:200m
m.a.s.l.
Rock Type
Type
Alteration
Fault Rock
Fault rock
Fractures
Open
0
15
Sealed
0
15
Crush
Sealed network
Interpretation
RU
BDZ
m.a.s.l
Depth
RU1a, 0-58 m.
Pegmatite, pegmatitic granite (101061) and granite to granodiorite, metamorphic (101057). Occurrences of felsic to intermediate volcanic rock, metamorphic (103076) and amphibolite (102017).
Confidence level = High.
BDZ1 17.5-33.5 m.
Increased fracture frequency, sealed networks and fault rocks (breccia and cataclasite). Zone cores at 27-27.5 m and 30-31 m. Alteration by sericitization, oxidation, chloritization and laumontitization.
Two fracture sets: One striking NNW and one NE. Both steeply dipping.
Confidence level = High

Page 2

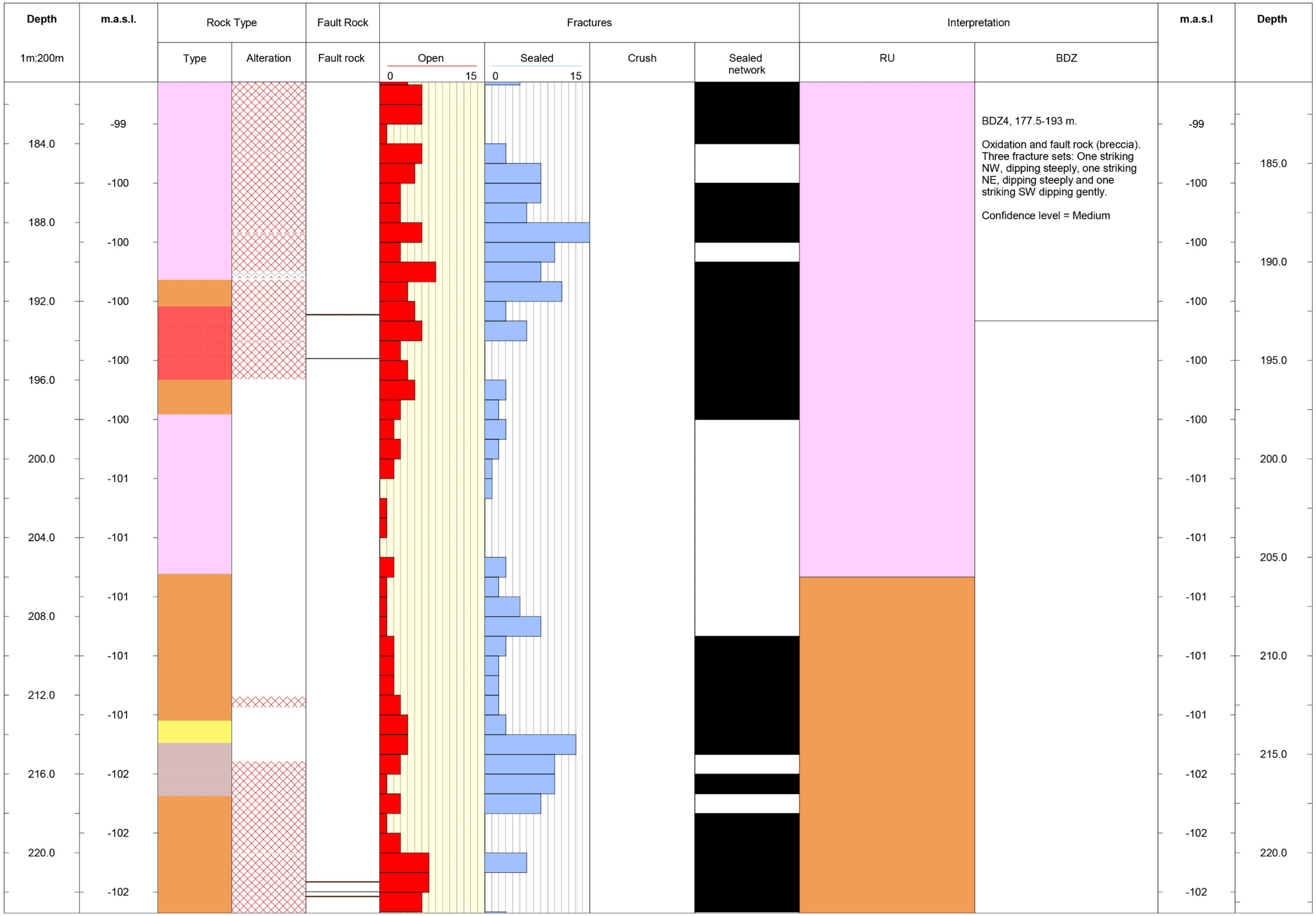

Depth
1m:200m
m.a.s.l.
Rock Type
Type
Alteration
Fault Rock
Fault rock
Fractures
Open
0
15
Sealed
0
15
Crush
Sealed network
Interpretation
RU
BDZ
m.a.s.l
Depth
56.0
60.0
64.0
68.0
72.0
76.0
80.0
84.0
88.0
92.0
96.0
-91
-92
-93
55.0
60.0
65.0
70.0
75.0
80.0
85.0
90.0
95.0
RU2, 58-92 m.
Pegmatite, pegmatitic granite (101061), felsic to intermediate volcanic rock, metamorphic (103076) and granite to granodiorite, metamorphic (101057).
Confidence level = High

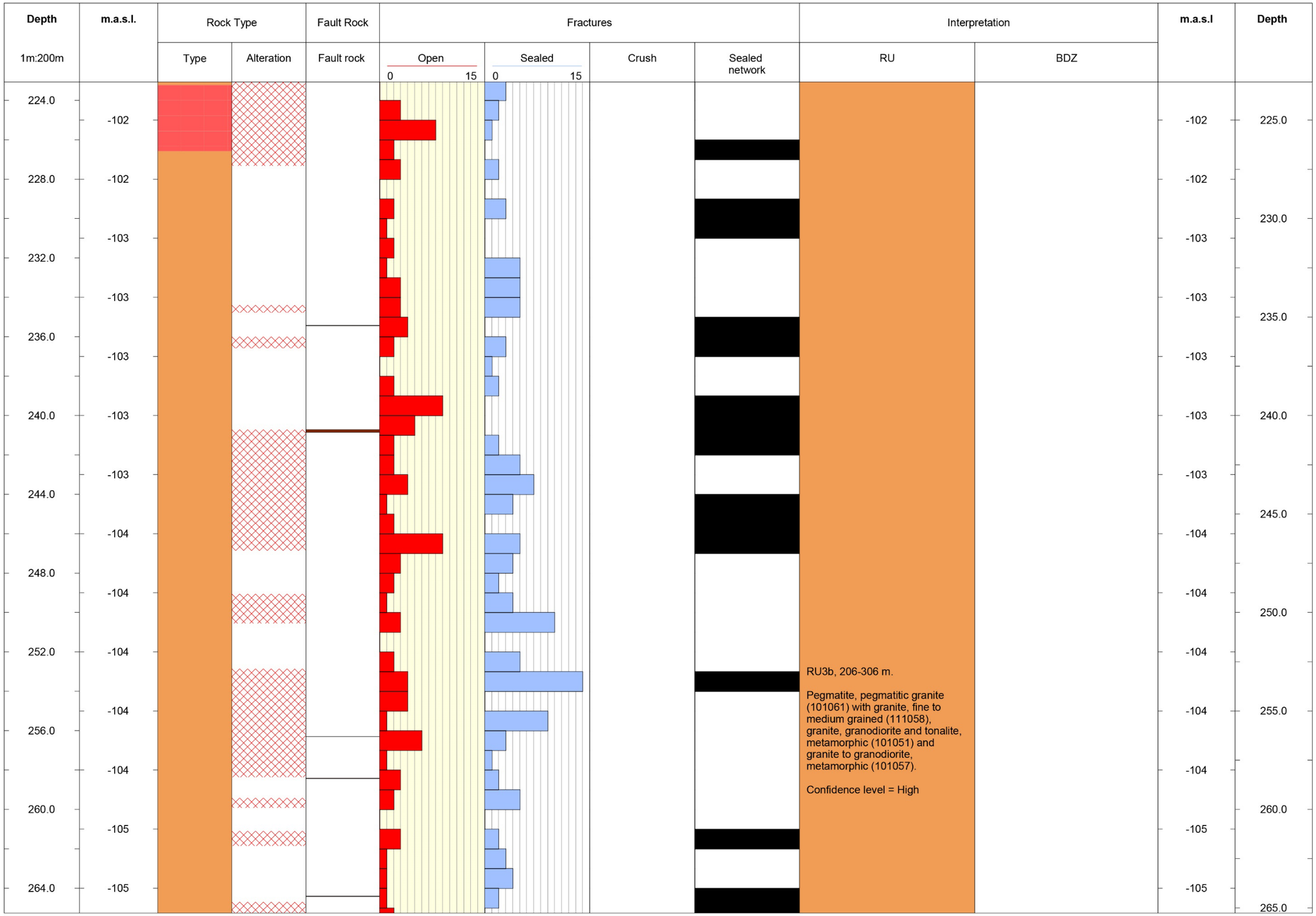

Depth
1m:200m
m.a.s.l.
Rock Type
Type
Alteration
Fault Rock
Fault rock
Fractures
Open
0
15
Sealed
0
15
Crush
Sealed network
Interpretation
RU
BDZ
m.a.s.l
Depth
RU3a, 92-128 m.
Pegmatite, pegmatitic granite (101061) and granite to granodiorite, metamorphic (101057) with occurrences of granite, fine to medium grained (111058).
Confidence level = High
BDZ2, 108-112.5 m.
Oxidation and fault rock (breccia). One fracture set striking NE and dipping steeply.
Confidence level = Low
RU3a, 112.72-131.17 m.
Pegmatitic granite (101061).
Confidence level = 3.
100.0
104.0
108.0
112.0
116.0
120.0
124.0
128.0
132.0
136.0
-94
-95
-96
105.0
110.0
115.0
125.0
130.0
135.0

Page 4


Depth
1m:200m
m.a.s.l.
Rock Type
Type
Alteration
Fault Rock
Fault rock
Fractures
Open
0
15
Sealed
0
15
Crush
Sealed network
Interpretation
RU
BDZ
m.a.s.l
Depth
140.0
144.0
148.0
152.0
156.0
160.0
164.0
168.0
172.0
176.0
180.0
-96
-97
-98
-99
145.0
150.0
155.0
165.0
170.0
175.0
RU4, 128-206 m.
Granite, granodiorite and tonalite, metamorphic (101051) with granite, fineto medium grained granite(111058), and pegmatite, pegmatitic granite (101061).
Confidence level = High
BDZ3, 159-173.5 m.
Increased fracture frequency, sealed network and fault rock (breccia). Alteration by oxidation and steatitization.
Two fracture sets: One striking NNE and one NW. Both steeply dipping.
Confidence level = High

Page 5


Depth
1m:200m
m.a.s.l.
Rock Type
Type
Alteration
Fault Rock
Fault rock
Fractures
Open
0
15
Sealed
0
15
Crush
Sealed network
Interpretation
RU
BDZ
BDZ4, 177.5-193 m.
Oxidation and fault rock (breccia). Three fracture sets: One striking NW, dipping steeply, one striking NE, dipping steeply and one striking SW dipping gently.
Confidence level = Medium
m.a.s.l
Depth
184.0
188.0
192.0
196.0
200.0
204.0
208.0
212.0
216.0
220.0
-99
-100
-101
-102
185.0
190.0
195.0
205.0
210.0
215.0


Depth
1m:200m
m.a.s.l.
Rock Type
Type
Alteration
Fault Rock
Fault rock
Fractures
Open
0
15
Sealed
0
15
Crush
Sealed network
Interpretation
RU
BDZ
m.a.s.l
Depth
224.0
228.0
232.0
236.0
240.0
244.0
248.0
252.0
256.0
260.0
264.0
-102
-103
-104
-105
225.0
230.0
235.0
240.0
245.0
250.0
255.0
260.0
265.0
RU3b, 206-306 m.
Pegmatite, pegmatitic granite (101061) with granite, fine to medium grained (111058), granite, granodiorite and tonalite, metamorphic (101051) and granite to granodiorite, metamorphic (101057).
Confidence level = High

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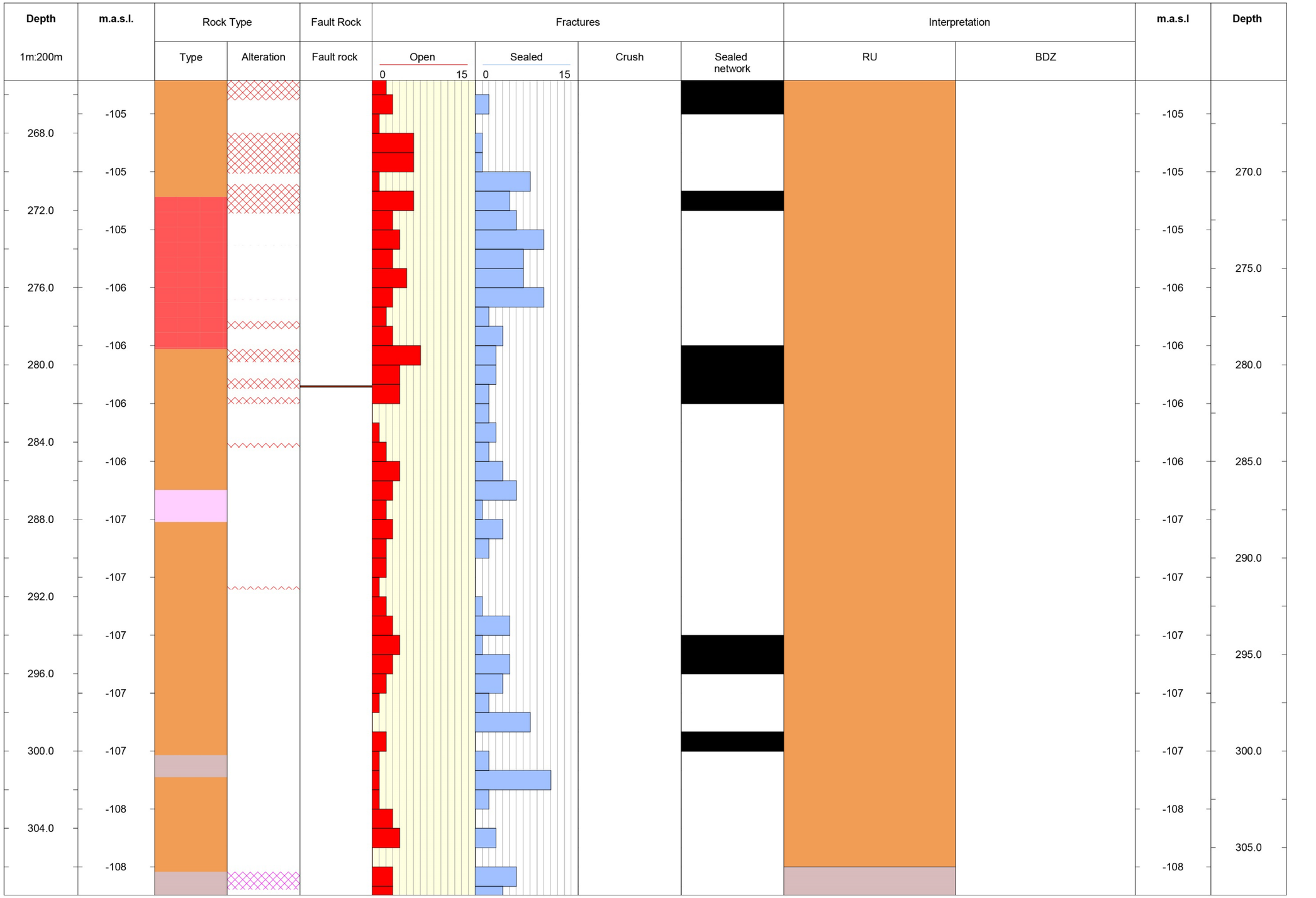
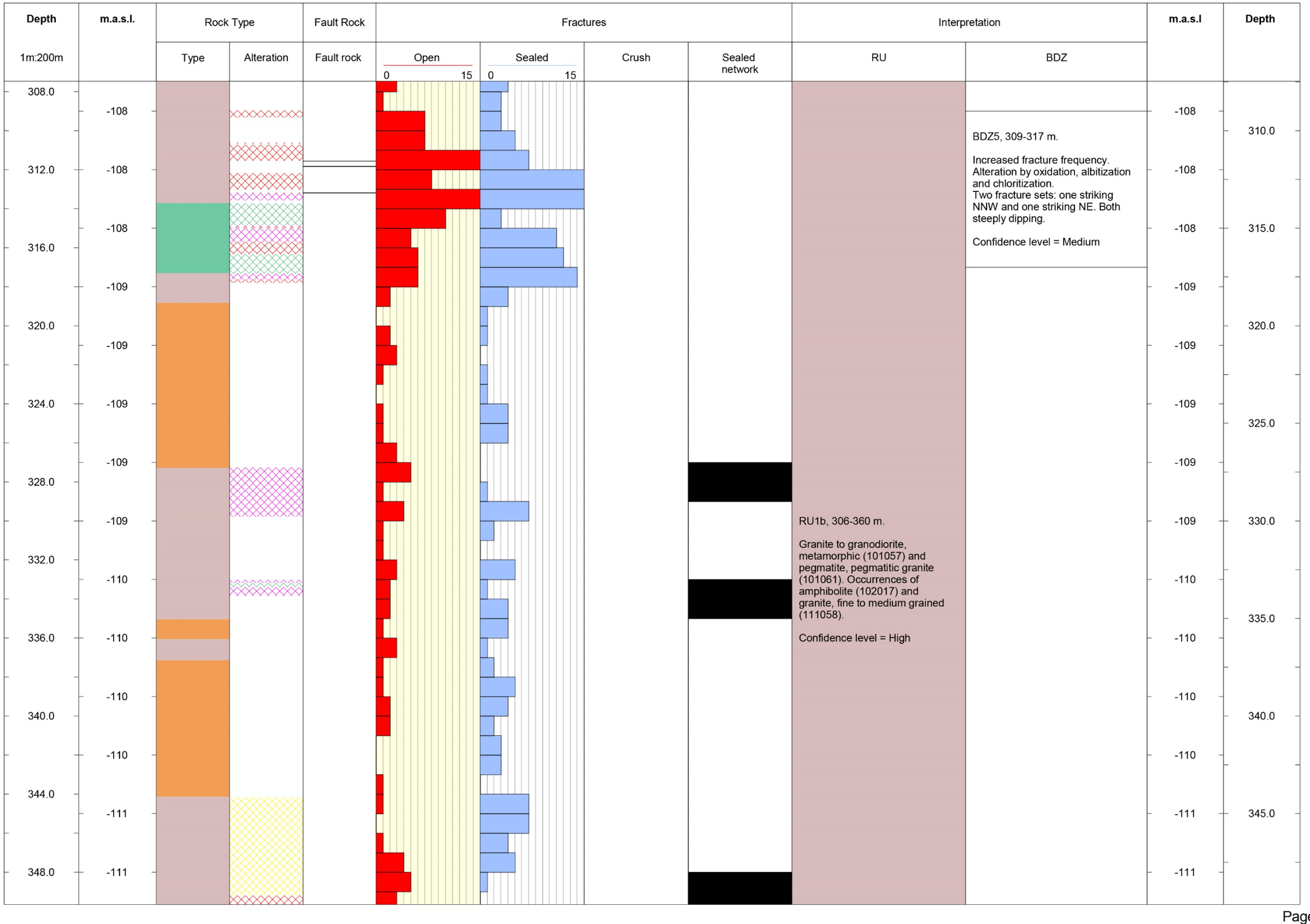
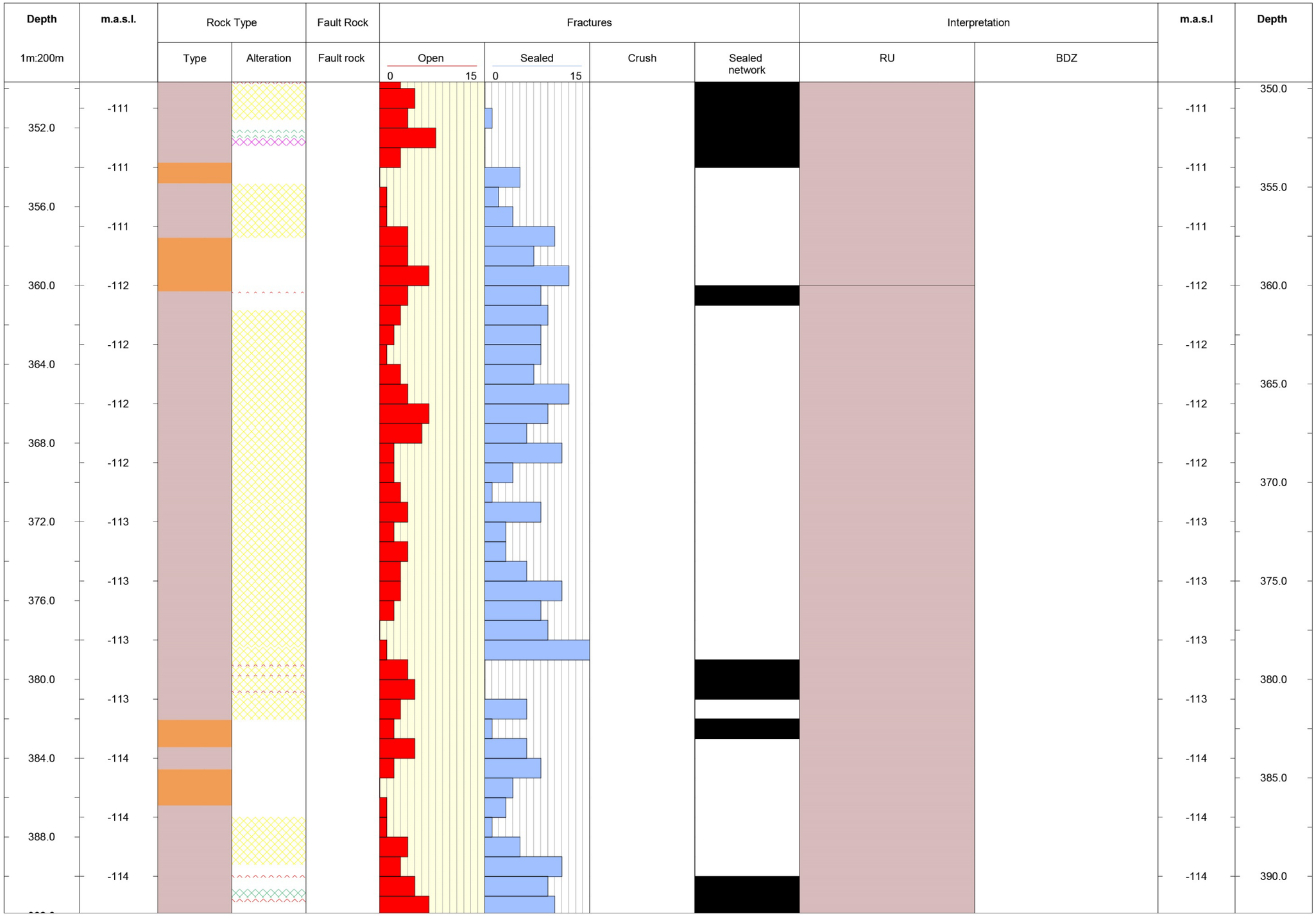
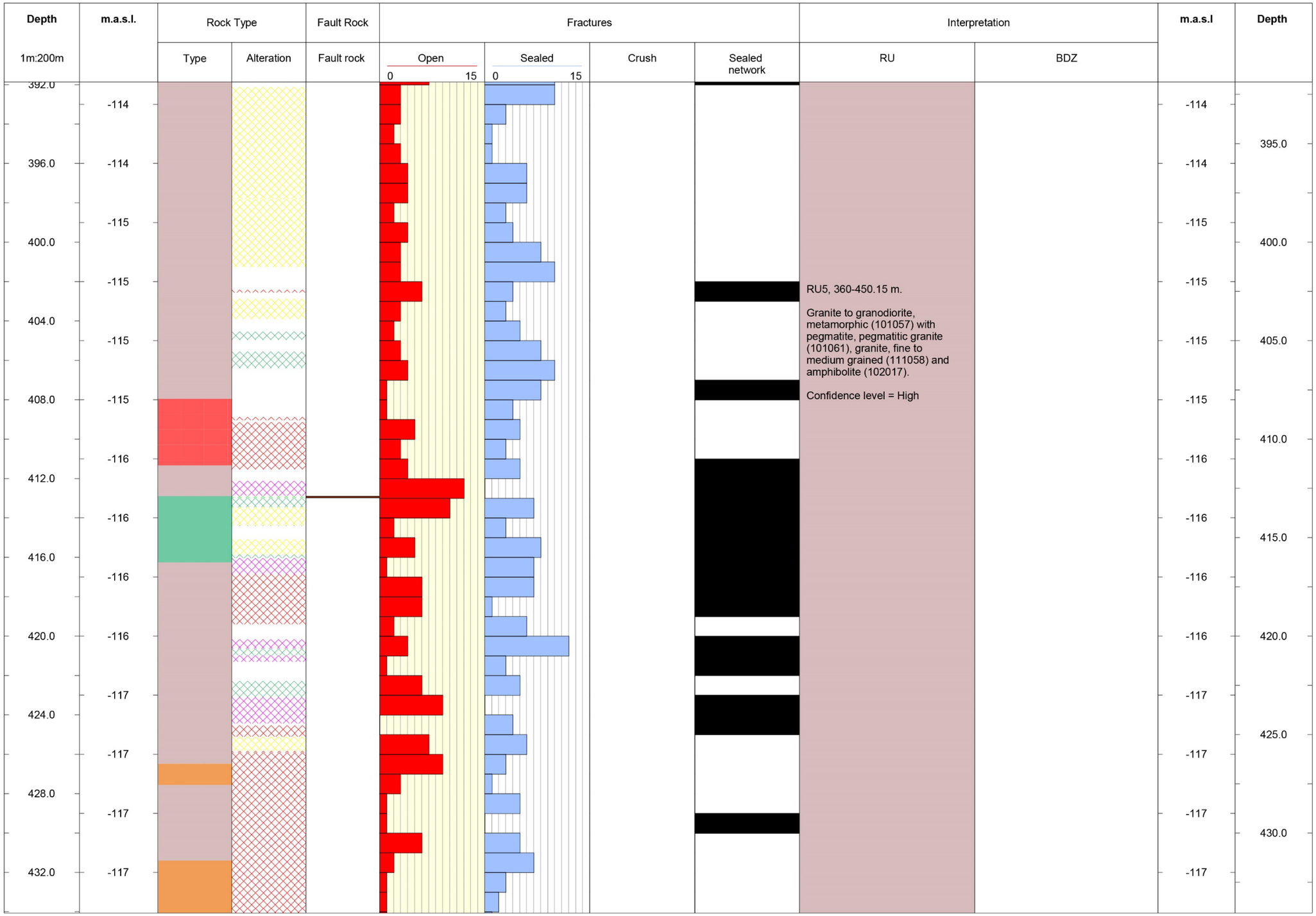
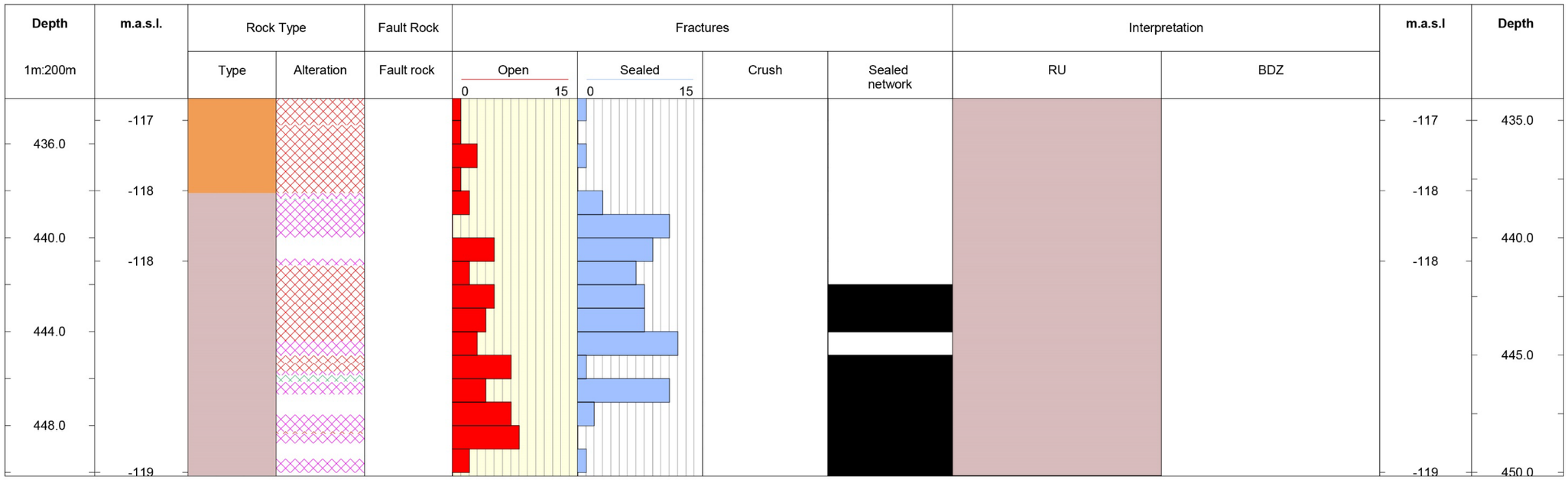

Depth
1m:200m
m.a.s.l.
Rock Type
Type
Alteration
Fault Rock
Fault rock
Fractures
Open
0
15
Sealed
0
15
Crush
Sealed network
Interpretation
RU
BDZ
m.a.s.l
Depth
-105
268.0
-105
272.0
-105
276.0
-106
280.0
-106
284.0
-106
288.0
-107
-107
292.0
-107
296.0
-107
300.0
-107
-108
304.0
-108
-105
-105
-105
-106
-106
-106
-107
-107
-107
-107
-107
-107
-108
-108
270.0
275.0
280.0
285.0
290.0
295.0
300.0
305.0


Depth
1m:200m
m.a.s.l.
Rock Type
Type
Alteration
Fault Rock
Fault rock
Fractures
Open
0
15
Sealed
0
15
Crush
Sealed network
Interpretation
RU
BDZ
m.a.s.l
Depth
308.0
312.0
316.0
320.0
324.0
328.0
332.0
336.0
340.0
344.0
348.0
-108
-109
-110
-111
310.0
315.0
320.0
325.0
330.0
335.0
340.0
345.0
BDZ5, 309-317 m.
Increased fracture frequency.
Alteration by oxidation, albitization and chloritization.
Two fracture sets: one striking NNW and one striking NE. Both steeply dipping.
Confidence level = Medium
RU1b, 306-360 m.
Granite to granodiorite, metamorphic (101057) and pegmatite, pegmatitic granite (101061). Occurrences of amphibolite (102017) and granite, fine to medium grained (111058).
Confidence level = High


Depth
1m:200m
m.a.s.l.
Rock Type
Type
Alteration
Fault Rock
Fault rock
Fractures
Open
0
15
Sealed
0
15
Crush
Sealed network
Interpretation
RU
BDZ
m.a.s.l
Depth
352.0
356.0
360.0
364.0
368.0
372.0
376.0
380.0
384.0
388.0
-111
-112
-113
-114
350.0
355.0
360.0
365.0
370.0
375.0
380.0
385.0
390.0


Depth
1m:200m
m.a.s.l.
Rock Type
Type
Alteration
Fault Rock
Fault rock
Fractures
Open
0
15
Sealed
0
15
Crush
Sealed network
Interpretation
RU
BDZ
m.a.s.l
Depth
392.0
396.0
400.0
404.0
408.0
412.0
416.0
420.0
424.0
428.0
432.0
-114
-115
-116
-117
395.0
405.0
410.0
415.0
425.0
430.0
RU5, 360-450.15 m.
Granite to granodiorite, metamorphic (101057) with pegmatite, pegmatitic granite (101061), granite, fine to medium grained (111058) and amphibolite (102017).
Confidence level = High


Depth
1m:200m
m.a.s.l.
Rock Type
Type
Alteration
Fault Rock
Fault rock
Fractures
Open
0
15
Sealed
0
15
Crush
Sealed network
Interpretation
RU
BDZ
m.a.s.l
Depth
436.0
440.0
444.0
448.0
-117
-118
-118
-119
-117
-118
-118
-119
435.0
440.0
445.0
450.0

Appendix 4

Borehole ID: KFR91

Diameter (mm): 76

Length (m): 340.11

Bearing (°): 133

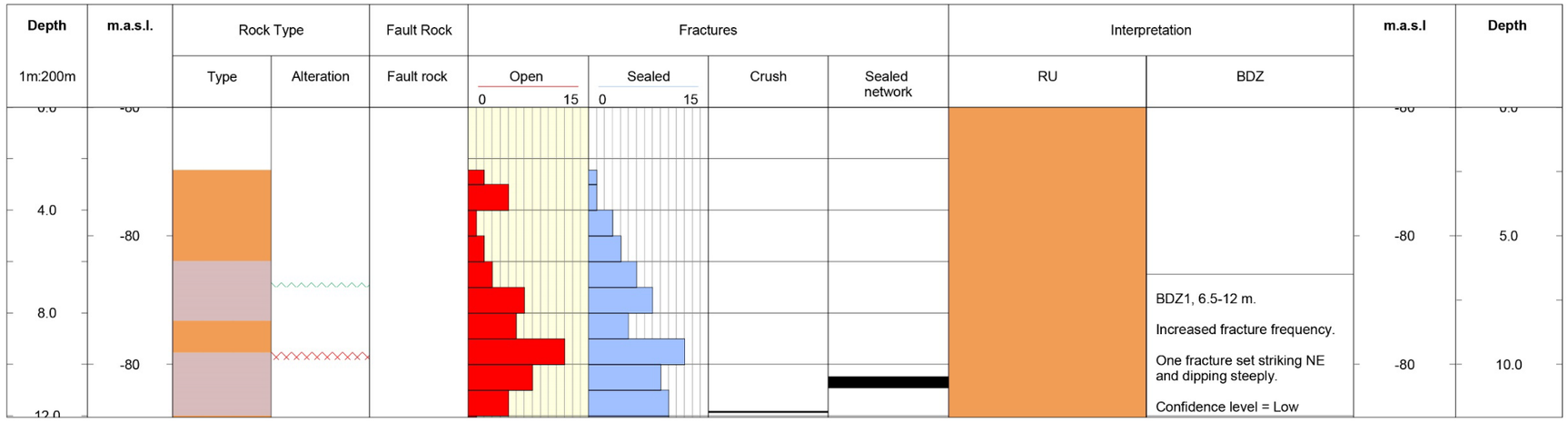
Inclination (°): -5

ROCK TYPE

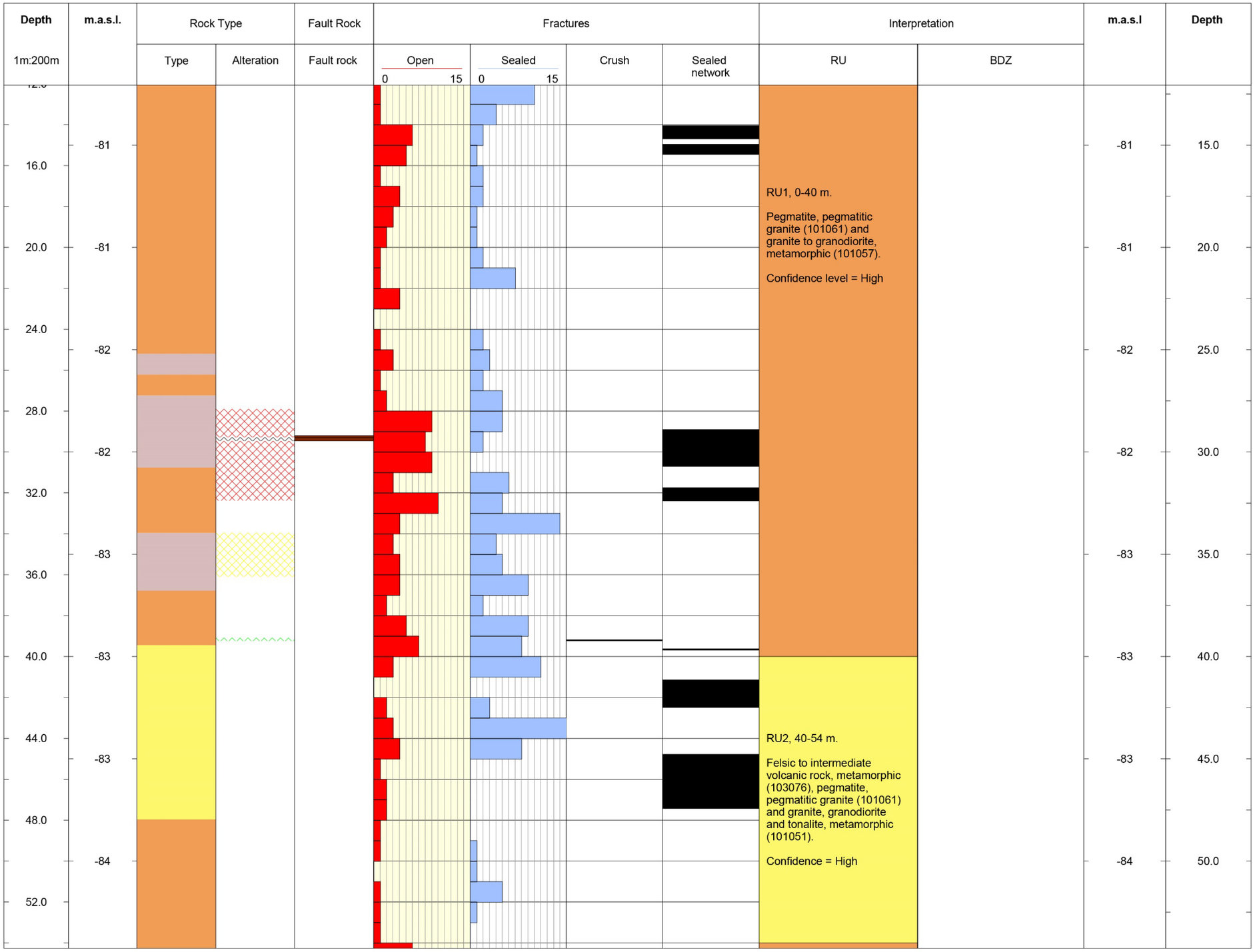
- Amfibolite
- Pegmatite, pegmatitic granite
- Granite, granodiorite and tonalite, metamorphic
- Granite to granodiorite, metamorphic
- Felsic to intermediate volcanic rock, metamorphic
- Granite, fine- to medium-grained

ROCK ALTERATION

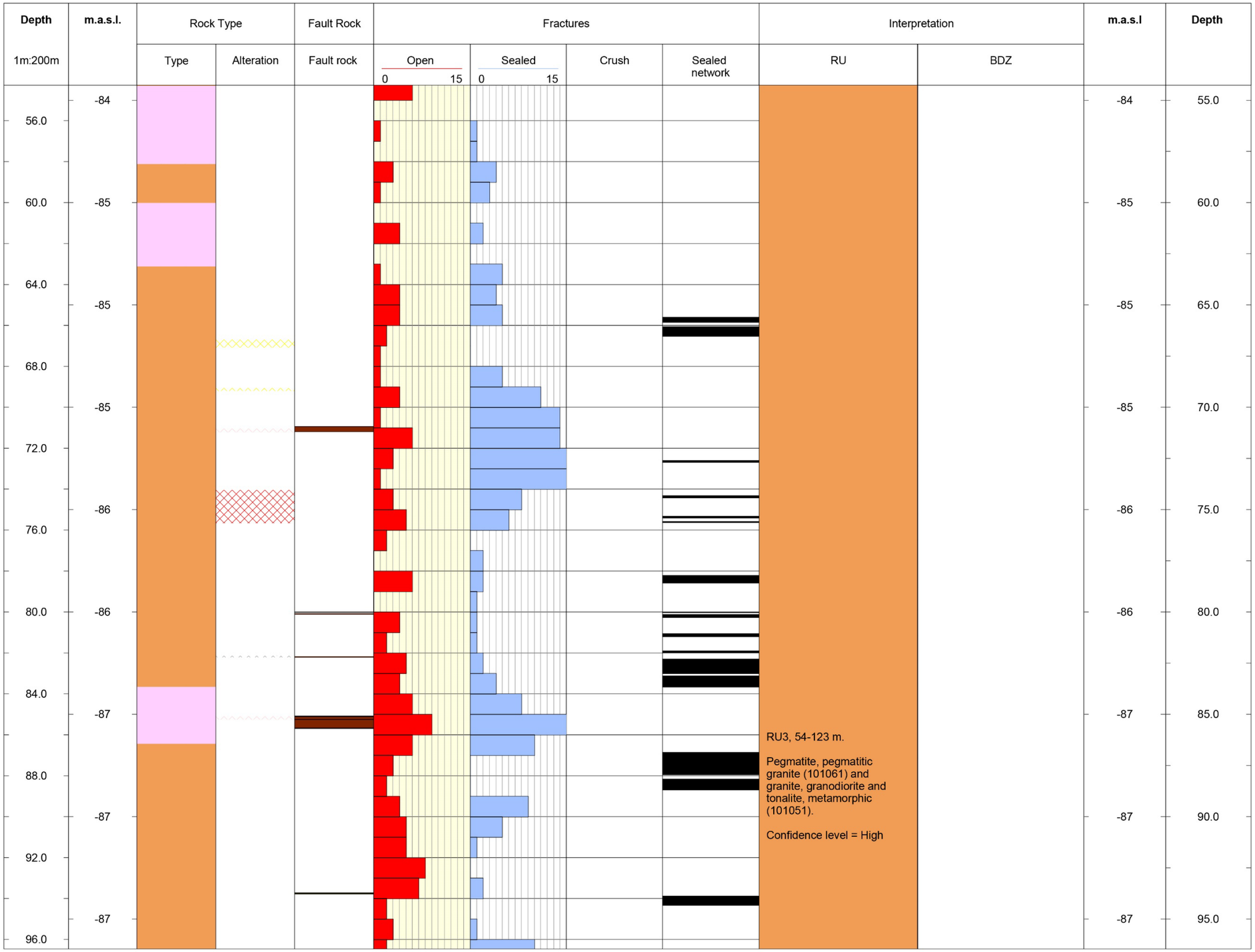
- Carbonatization
- Argillization
- Lamontization
- Chloritization
- Oxidation
- Sericitization
- Albitization
- Steatitization



Page 1


Depth
1m:200m
m.a.s.l.
Rock Type
Type
Alteration
Fault Rock
Fault rock
Fractures
Open
0
15
Sealed
0
15
Crush
Sealed network
Interpretation
RU
BDZ
m.a.s.l
Depth
-81
-81
-82
-82
-83
-83
-83
-84
16.0
20.0
24.0
28.0
32.0
36.0
40.0
44.0
48.0
52.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
RU1, 0-40 m.
Pegmatite, pegmatitic granite (101061) and granite to granodiorite, metamorphic (101057).
Confidence level = High
RU2, 40-54 m.
Felsic to intermediate volcanic rock, metamorphic (103076), pegmatite, pegmatitic granite (101061) and granite, granodiorite and tonalite, metamorphic (101051).
Confidence = High

Page 2


Depth
1m:200m
m.a.s.l.
Rock Type
Type
Alteration
Fault Rock
Fault rock
Fractures
Open
0
15
Sealed
0
15
Crush
Sealed network
Interpretation
RU
BDZ
m.a.s.l
Depth
-84
56.0
-85
60.0
64.0
-85
68.0
-85
72.0
-86
76.0
-86
80.0
84.0
-87
88.0
-87
92.0
-87
96.0
55.0
60.0
65.0
70.0
75.0
80.0
85.0
90.0
95.0
RU3, 54-123 m.
Pegmatite, pegmatitic granite (101061) and granite, granodiorite and tonalite, metamorphic (101051).
Confidence level = High

Page 3

Depth	m.a.s.l.	Rock Type		Fault Rock	Fractures				Interpretation		m.a.s.l	Depth
1m:200m		Type	Alteration	Fault rock	Open 0 15	Sealed 0 15	Crush	Sealed network	RU	BDZ		
100.0	-88										-88	100.0
104.0	-88										-88	105.0
108.0	-89										-89	110.0
112.0	-89										-89	115.0
116.0												
120.0	-90										-90	120.0
124.0	-90										-90	125.0
128.0	-91										-91	130.0
132.0												
136.0	-91										-91	135.0

BDZ2, 131.5-147 m.

Increased fracture frequency, crushes, sealed networks and fault rocks. Alteration by chloritization, sericitization, oxidation and steatitization.

Depth	m.a.s.l.	Rock Type		Fault Rock	Fractures				Interpretation		m.a.s.l	Depth
1m:200m		Type	Alteration	Fault rock	Open 0 15	Sealed 0 15	Crush	Sealed network	RU	BDZ		
140.0	-92									Three fracture sets: one striking E dipping moderately, one striking N dipping steeply and one striking SW dipping steeply. Hydraulically conductive. PFL = 8,40E-07 m2/s. Confidence level = Medium	-92	140.0
144.0	-92										-92	145.0
148.0	-93								RU4, 123-180 m. Pegmatite, pegmatitic granite (101061), granite to granodiorite, metamorphic (101057) and amphibolite (102017). Confidence level = High		-93	150.0
152.0												
156.0	-93										-93	155.0
160.0	-94										-94	160.0
164.0	-94										-94	165.0
168.0	-95										-95	170.0
172.0												
176.0	-95										-95	175.0
180.0	-96										-96	180.0

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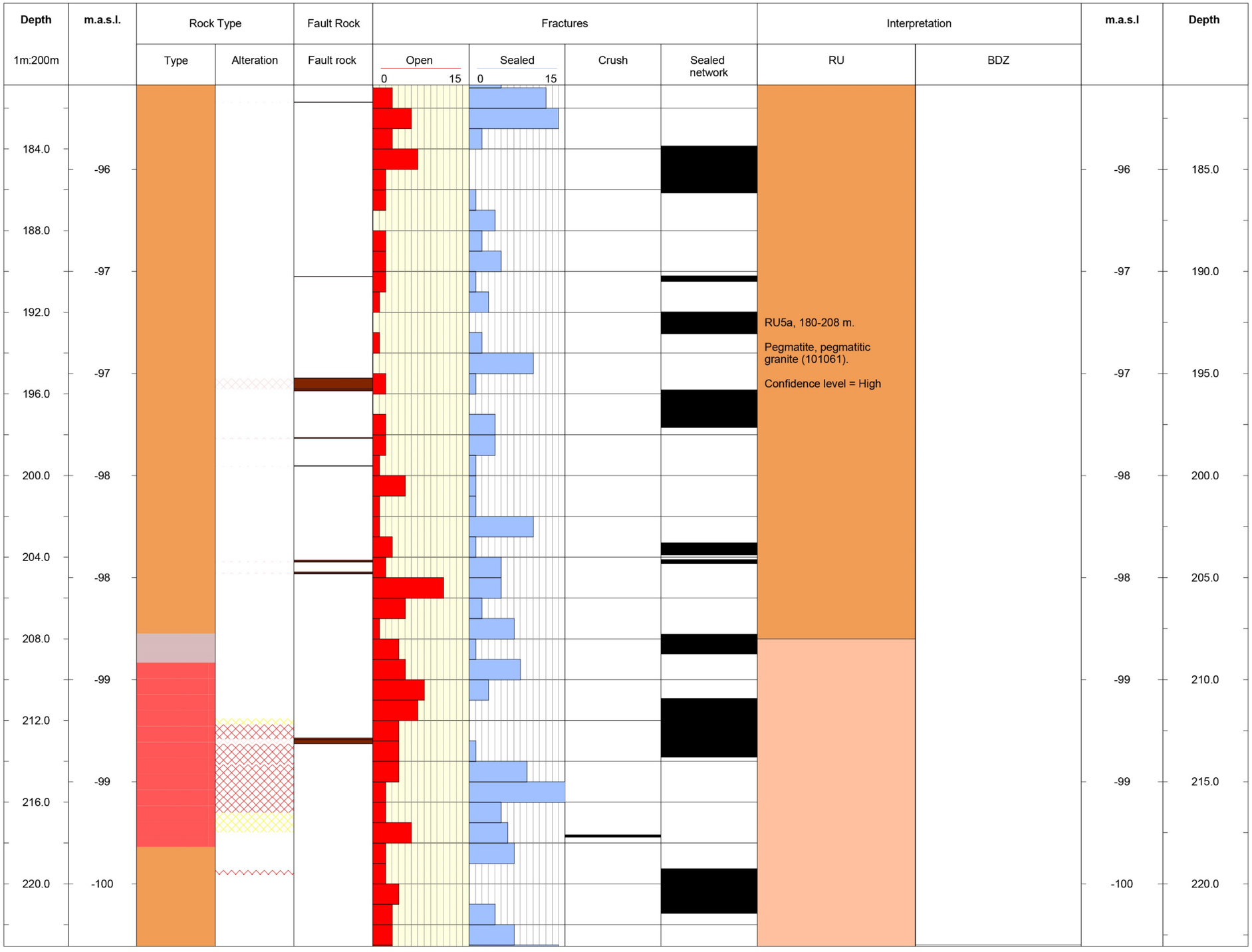
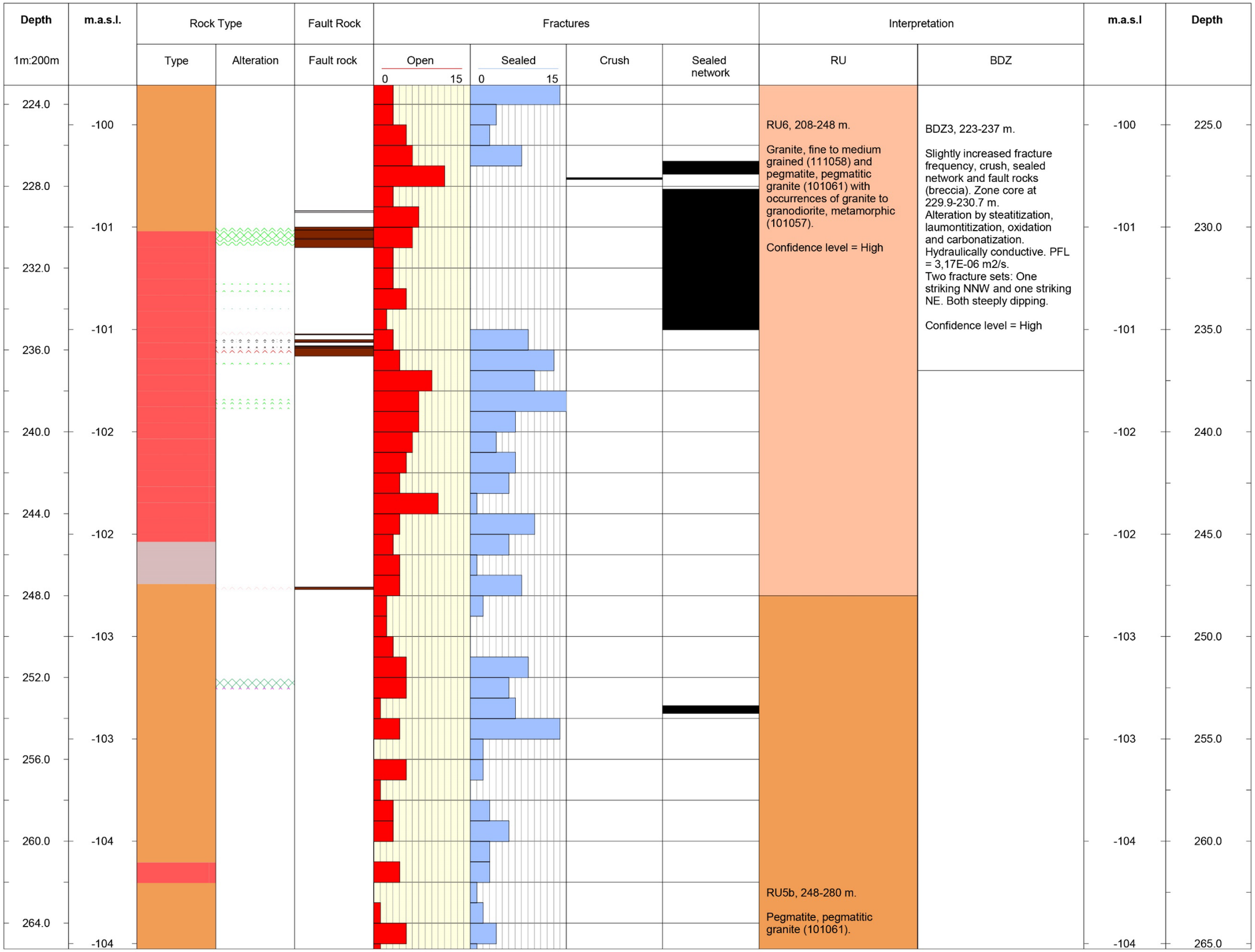
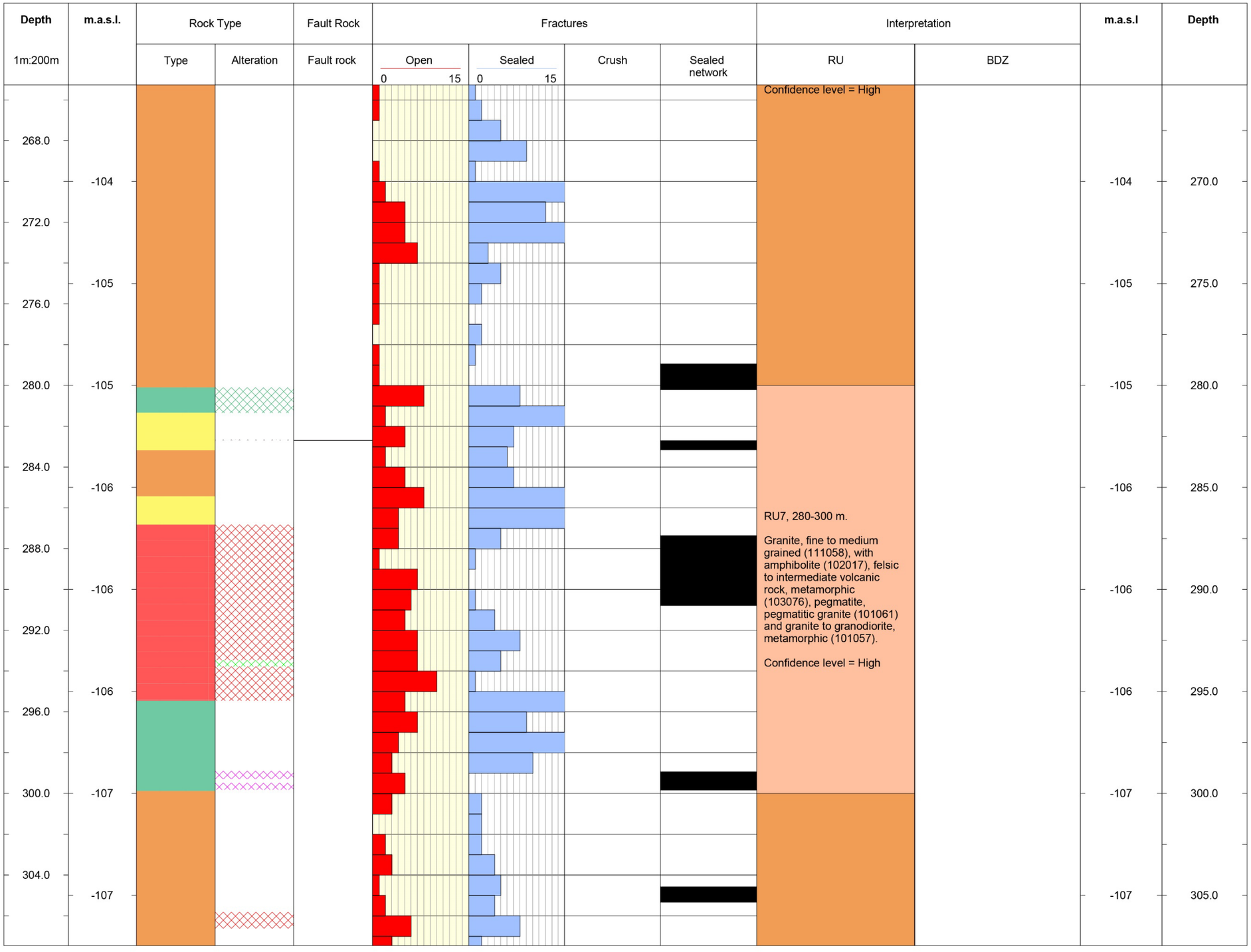
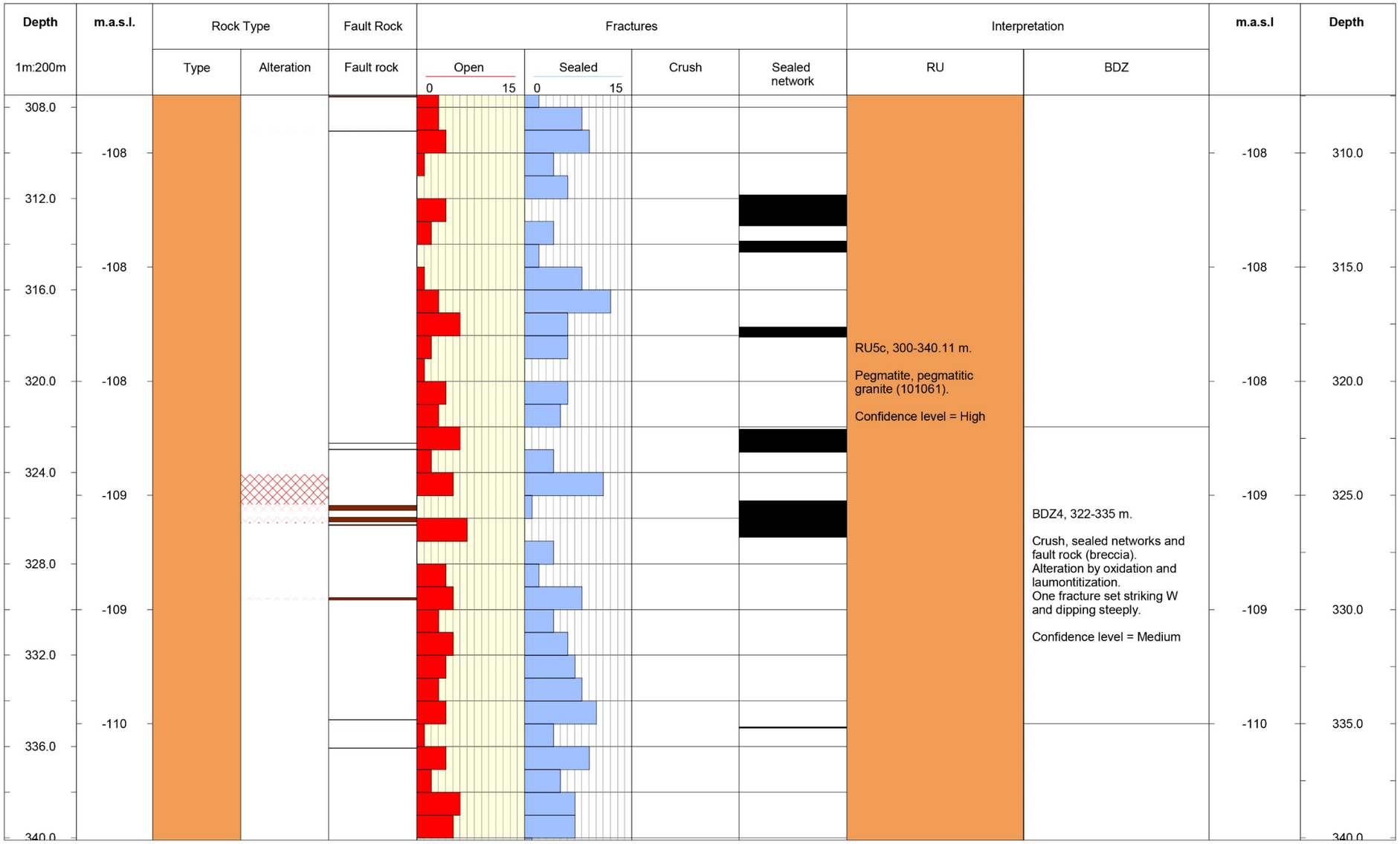

Depth
1m:200m
m.a.s.l.
Rock Type
Type
Alteration
Fault Rock
Fault rock
Fractures
Open
0
15
Sealed
0
15
Crush
Sealed network
Interpretation
RU
BDZ
m.a.s.l
Depth
184.0
-96
188.0
-97
192.0
-97
196.0
200.0
-98
204.0
-98
208.0
-99
212.0
-99
216.0
220.0
-100
RU5a, 180-208 m.
Pegmatite, pegmatitic granite (101061).
Confidence level = High
-96
185.0
-97
190.0
-97
195.0
-98
200.0
-98
205.0
-99
210.0
-99
215.0
-100
220.0

Page 6


Depth
1m:200m
m.a.s.l.
Rock Type
Type
Alteration
Fault Rock
Fault rock
Fractures
Open
0
15
Sealed
0
15
Crush
Sealed network
Interpretation
RU
BDZ
m.a.s.l
Depth
224.0
228.0
232.0
236.0
240.0
244.0
248.0
252.0
256.0
260.0
264.0
-100
-101
-101
-102
-102
-103
-103
-104
-104
RU6, 208-248 m.
Granite, fine to medium grained (111058) and pegmatite, pegmatitic granite (101061) with occurrences of granite to granodiorite, metamorphic (101057).
Confidence level = High
RU5b, 248-280 m.
Pegmatite, pegmatitic granite (101061).
BDZ3, 223-237 m.
Slightly increased fracture frequency, crush, sealed network and fault rocks (breccia). Zone core at 229.9-230.7 m.
Alteration by steatitization, laumontitization, oxidation and carbonatization.
Hydraulically conductive. PFL = 3,17E-06 m2/s.
Two fracture sets: One striking NNW and one striking NE. Both steeply dipping.
Confidence level = High
-100
-101
-101
-102
-102
-103
-103
-104
-104
225.0
230.0
235.0
240.0
245.0
250.0
255.0
260.0
265.0


Depth
1m:200m
m.a.s.l.
Rock Type
Type
Alteration
Fault Rock
Fault rock
Fractures
Open
0
15
Sealed
0
15
Crush
Sealed network
Interpretation
RU
BDZ
m.a.s.l
Depth
Confidence level = High
RU7, 280-300 m.
Granite, fine to medium grained (111058), with amphibolite (102017), felsic to intermediate volcanic rock, metamorphic (103076), pegmatite, pegmatitic granite (101061) and granite to granodiorite, metamorphic (101057).
Confidence level = High
268.0
272.0
276.0
280.0
284.0
288.0
292.0
296.0
300.0
304.0
-104
-105
-105
-106
-106
-106
-107
-107
-104
-105
-106
-106
-107
270.0
275.0
280.0
285.0
290.0
295.0
300.0
305.0


Depth
1m:200m
m.a.s.l.
Rock Type
Type
Alteration
Fault Rock
Fault rock
Fractures
Open
0
15
Sealed
0
15
Crush
Sealed network
Interpretation
RU
BDZ
m.a.s.l
Depth
308.0
312.0
316.0
320.0
324.0
328.0
332.0
336.0
340.0
-108
-108
-108
-109
-109
-110
310.0
315.0
320.0
325.0
330.0
335.0
RU5c, 300-340.11 m.
Pegmatite, pegmatitic granite (101061).
Confidence level = High
BDZ4, 322-335 m.
Crush, sealed networks and fault rock (breccia).
Alteration by oxidation and laumontitization.
One fracture set striking W and dipping steeply.
Confidence level = Medium