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Determination of Q_{bas} and RMR_{bas} for the cored boreholes KFR117–121

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Summary

This report presents the determination of Q_{bas} and RMR_{bas} of the core drilled boreholes KFR117–121. The boreholes are drilled from the pier above the SFR facility and the boreholes are mapped with the Boremap system according to SKB MD 143.006.

The mapping data for KFR117–121 is retrieved from SICADA and characterized in 5 m-intervals in accordance with the method description SKB MD 170.001e *Determination of Qbas and RMRbas based on core mapping.*

The rock quality for KFR117–121 is generally good for all five boreholes. The lowest Q_{bas} values are intervals classified as *fair,* but the majority falls into the rock quality class *good* or higher.

According to RMR_{bas} the rock quality in KFR117–121 is generally classified as *good*, and just a few intervals as *fair* or *very good*.

Sammanfattning

Denna rapport presenterar resultatet av karaktäriseringen enligt Q_{bas} och RMR_{bas} för kärnborrhålen KFR117–121. Borrhålen är borrade från piren över SFR-anläggningen och kärnorna karterade med Boremapsystemet i enlighet med SKB MD 143.006.

Karteringsdata för KFR117–121 är hämtat från SICADA och karaktäriserat i 5 m-intervall i enlighet med metodbeskrivningen SKB MD 170.001e *Determination of Qbas and RMRbas based on core mapping.*

Bergkvaliteten för KFR117–121 är i allmänhet god för alla fem borrhålen. De lägsta Q_{bas}-värdena är intervall klassificerade som *acceptabel*, men huvuddelen faller i bergkvalitetsklassen *bra* eller högre.

Enligt RMR_{bas} klassificeras bergskvaliteten i KFR117–121 i allmänhet som *bra* och bara några få intervaller som *acceptabel* eller *mycket bra*.

Contents

1 Introduction 7

2 Methodology 9
2.1 Defining borehole intervals 9
2.2 Q_{bas} 9
2.2.1 RQD/J_n 10
2.2.2 J_r/J_a 10
2.2.3 Q_{bas} value 11
2.3 RMR_{bas} 11
2.3.1 R1 – strength of intact rock 11
2.3.2 R2 + R3 – discontinuity density 12
2.3.3 R4 – condition of discontinuities 13
2.3.4 R5 – groundwater conditions 15
2.3.5 RMR_{bas} value 15
2.3.6 Rock mass classification 15

3 Result 17
3.1 KFR117 17
3.2 KFR118 18
3.3 KFR119 19
3.4 KFR120 20
3.5 KFR121 21

4 Delivery and storage of results 23

References 25

1 Introduction

To create capacity for storage of demolition waste from the Swedish nuclear power plants and the increased amount of operational waste caused by the extended operating time of the remaining nuclear power plants, SKB plans to expand the existing repository of low- and intermediate-level waste, SFR. The expansion is planned in conjunction to the existing facility, located under the sea outside Stora Asphällan.

For the planned expansion, SKB initiated an investigation program, which involves the drilling of five cored boreholes, KFR117–121, to identify the possible existence of sub-horizontal water-bearing structures in the shallow rock mass.

This report presents the Q_{bas} and RMR_{bas} characterization of the cored boreholes KFR117–121, drilled from the pier above the SFR facility. The boreholes were drilled during the period of April to June 2020 and mapped with the Boremap system (SKB MD 143.006) in May to November 2020.

The characterization is performed and documented in accordance with the controlling documents listed in Table 1-1.

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

Documents	Number	Version
Boremapkartering av KFR117–KFR121	AP SFK-20-004	1.0
Determination of Qbas and RMRbas based on core mapping	SKB MD 170.001e	1.0

2 Methodology

The characterization is performed in accordance with the method description *Determination of Qbas and RMRbas based on core mapping* (Hakami 2020).

The mapping data for KFR117–121 are retrieved from SICADA and the used parameter tables are listed in Table 2-1.

The boreholes are characterized in 5-meter intervals.

Table 2-1. The SICADA parameter tables used for characterization.

Parameter table from SICADA
p_freq_5m
p_freq_1m
p_fract_core
p_fract_crush
p_rock
p_rock_occur
p_rock_alter
p_rdq

2.1 Defining borehole intervals

The 5 m-intervals for characterization can either be determined from the parameter table p_freq_5m or chosen as desired if the intervals are the same for both Q_{bas} and RMR_{bas} in the same borehole.

Due to problems in SICADA for the new mapping activity GE064, there was no data in the p_freq_5m table when starting the characterization for boreholes KFR117 and KFR120. The first 5 m-interval for these two boreholes starts where the actual mapping start. For borehole KFR118, KFR119 and KFR121 the p_freq_5m table were used for defining the 5 m-intervals. Using the p_freq_5m table results in a first and last interval with shorter length than 5 m.

2.2 Q_{bas}

The Q-system (The tunneling quality index) is a classification system for rock masses in underground designs developed by Norwegian Geotechnical Institute (NGI 2015).

Based on the six rock mass parameters in Equation (2-1) a Q-value can be calculated giving a description of the rock mass quality.

$$Q = \left(\frac{RQD}{J_n}\right) \cdot \left(\frac{J_r}{J_a}\right) \cdot \left(\frac{J_w}{SRF}\right) \qquad (2\text{-}1)$$

RQD, Rock Quality Designation,

J_n, joint set number,

J_r, joint roughness number,

J_a, joint alteration number,

J_w, joint water reduction factor, and

SRF, stress reduction factor.

When calculating the Q_{bas} value for drill cores the rock mass is considered in an undisturbed state and the external factors *joint water reduction factor* J_w and *the stress reduction factor*, SRF are not regarded. Both J_w and SRF are set to 1, corresponding to dry and favorable stress conditions, respectively.

2.2.1 RQD/J_n

RQD is the sum of all core pieces longer than 0.1 m as percentage of the total core length.

RQD is provided by the SICADA parameter table p_rqd, which is based on open fractures and fractures in mapped crush zones. For the characterization a mean value is calculated for each 5 m-intervals.

The joint set number (J_n) is determined by plotting all fracture orientation data, or data from parts of the borehole, in a stereogram to identify existing fracture sets using Terzaghi correction. A J_n-number is determined for each 5 m-interval using Table 2-2.

Table 2-2. Joint set number.

	Joint set number	J_n
A	Massive, no or few joints	0.5–1
B	One joint set	2
C	One joint set plus random joints	3
D	Two joint sets	4
E	Two joint sets plus random joints	6
F	Three joint sets	9
G	Three joint sets plus random joints	12
H	Four or more joint sets, random heavily jointed “sugar cube”, etc	15
J	Crushed rock, earth like	20

The RQD-values are then divided by the J_n-numbers for each 5 m-interval of the borehole.

2.2.2 J_r/J_a

The *joint roughness number*, J_r, is determined from the fracture parameters *roughness* and *surface* and are stored in the SICADA parameter table p_fract_core and p_fract_crush (for intervals containing crush zones), Table 2-3.

Table 2-3. Joint roughness number.

Roughness	Roughness code	Surface	Surface code	J_r
Irregular	4	Rough	1	4
	4	Smooth	2	3
	4	Slickensided	3	2
Stepped	3	Rough	1	4
	3	Smooth	2	3
	3	Slickensided	3	2
Undulating	2	Rough	1	3
	2	Smooth	2	2
	2	Slickensided	3	1.5
Planar	1	Rough	1	1.5
	1	Smooth	2	1
	1	Slickensided	3	0.5

After the J_r and J_a number is determined, the ratio J_r/J_a is calculated for all open fracture. For 1 m-intervals with no fractures, the J_r/J_a ratio is set to 5.33, corresponding to a J_r- and J_a number of 4 and 0.75, respectively.

Finally, a mean value of the five lowest J_r/J_a-ratios is calculated for each 5 m-interval in the borehole.

2.2.3 Q_{bas} value

The Q_{bas} value for each 5 m-interval is calculated as the product of the RQD/Jn and J_r/J_a according to Equation (2-1). These values are reported and stored in SICADA.

2.3 RMR_{bas}

The RMR-system (Rock Mass Rating) is a classification where five different rock mass parameters are rated and added according to Equation (2-2), resulting in different rock quality classes.

The most widely used version of RMR is RMR_{89} published by Bieniawski (1989). The updated version from 2013 (Lowson and Bieniawski 2013) is used in this project for characterization of KFR117–121. In this version the rating for R1, strength of intact rock, and R2+R3, *discontinuity density* is directly given from two charts. The *discontinuity density* is a new parameter combining the two parameters RQD and *joint spacing* in version RMR_{89}.

$$RMR_{2013} = R_1 + (R_2 + R_3) + R_4 + R_5 \tag{2-2}$$

R_1 – Rating of intact rock strength,

$R_2 + R_3$ – Rating of discontinuity density,

R_4 – Rating of discontinuity condition,

R_5 – Rating of ground water conditions (assuming “dry conditions” for RMR_{bas}).

When calculating the RMR_{bas} value for drill cores the rock mass is considered in an undisturbed state and the groundwater rating, R5, is set to 15, corresponding to completely dry conditions. Nor is any rating reduction done for unfavorable fracture orientations in relation to tunnel direction.

2.3.1 R1 – strength of intact rock

The rating of R1 is given by the chart in Figure 2-1 as a function of the uniaxial compressive strength, UCS. The average value of the uniaxial compressive strength for the most common rock types in Forsmark are given in Table 2-4. It should be noted that these values are for rock types in, or adjacent to the tectonic lens. The same rock types north of the Singö zone in the SFR-area are structurally and texturally slightly different with a higher degree of deformation, which can affect the uniaxial compressive strength.

Table 2-4. The average value of the uniaxial compressive strength for rock types in Forsmark (modified from Hakami 2020).

Rock code	**101057**	**101057_Alb**	**101061**	**101058**	**111058**	**103076**	**102017**
Rock type name	**Granite to granodiorite**	**Granite to granodiorite** **Albitized**	**Pegmatite, pegmatitic granite**	**Granite, metamorphic, aplitic**	**Fine- to medium-grained granite**	**Felsic to intermediate metavolcanic rock**	**Amphibolite**
UCS (MPa)	226	373	183	310	280	139	142

The rating for the rock strength is given for 5 m-intervals calculated from the SICADA parameter tables p_rock, p_rock_occur and p_rock_alter.

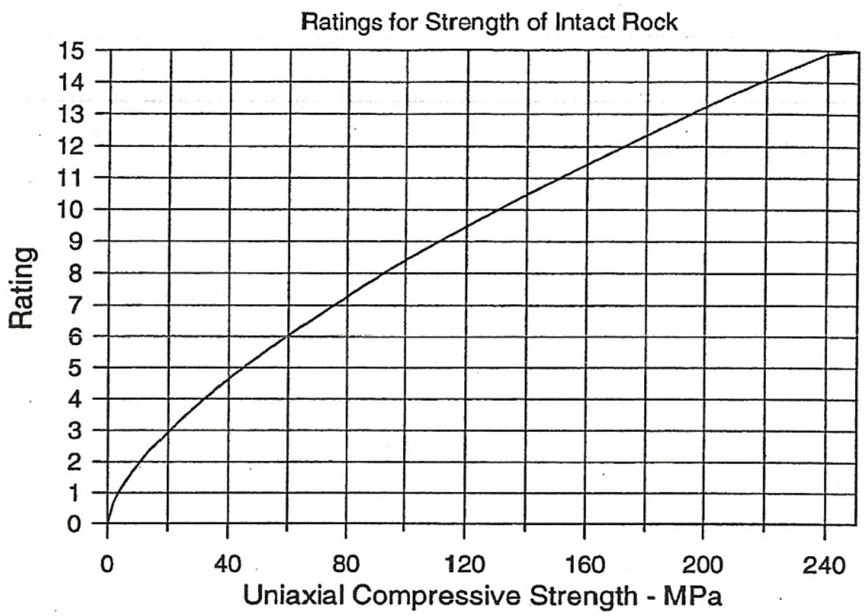

Figure 2-1. *The R1 as a function of the uniaxial compressive strength.*

If the rock types vary in the interval, a weighted average is calculated for the occurring rock types. If there are rock occurrences (rock types < 1 m in length) or rock type alterations with lower strength than the rock type, occupying more than one meter of the 5 m-interval, they are included in the calculation. The percentage reduction of the UCS-value used for different alterations are listed in Table 2-5. The reduction in strength is mainly based on qualified guesses due to lack of test data. If two or more alterations overlap, only the alteration leading to the lowest strength is considered in the calculation.

Table 2-5. The percentage reduction of UCS for different alterations.

Alteration type	Percentage reduction of UCS (%)	
	Medium intensity	Strong intensity
Sericitization (muscovitization)	−10	−20
Lamontization	−15	−30
Oxidation	−7	−14
Chloritization	−10	−20
Argillization	−15	−30

Albitization is increasing the UCS-value by 65 % and albititized metagranite (rock code 101057) is treated as a separate rock type, see Table 2-4. The UCS-data in Table 2-4 are from strongly albititized metagranite. The same value is however used for medium albitization in the characterization since this alteration intensity is assumed to give a higher UCS-value than 240 MPa, giving the highest rating in Figure 2-1.

2.3.2 R2 + R3 – discontinuity density

In RMR_{2013} the R2 term for RQD is combined with the R3 term for *spacing of discontinuity* into a single rating called *discontinuity density.* The rating for R2+R3 is given by the chart in Figure 2-2.

The fracture frequency for 5 m-intervals is provided by the SICADA parameter table p_freq_5m, or for 1 m-intervals by parameter table p_freq_1m. The average value for 1 m in each 5 m-interval of the borehole is calculated and the corresponding rating for discontinuity density (R2+R3) is obtained from Figure 2-2.

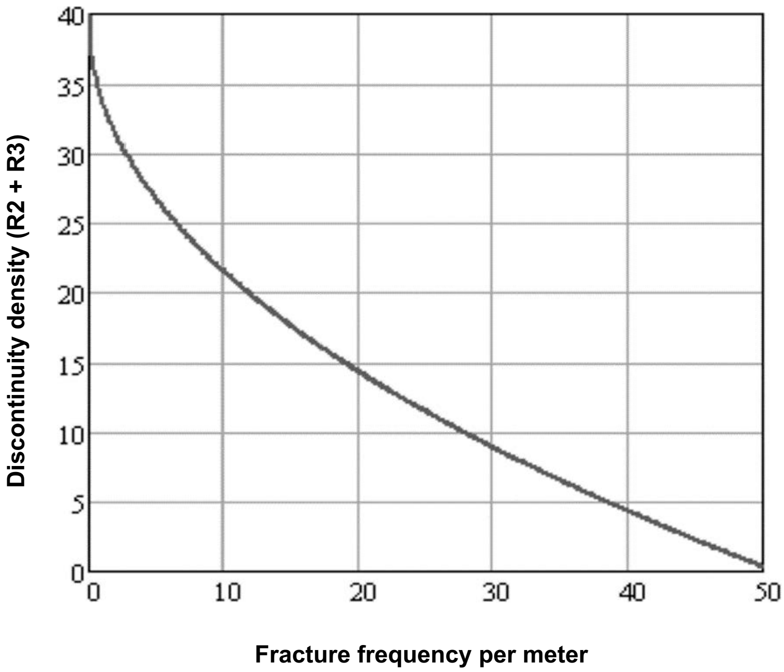

Figure 2-2. *The rating of R2 + R3 as a function of fracture frequency (modified from Lowson and Bieniawski 2013).*

2.3.3 R4 – condition of discontinuities

Conditions of discontinuities include aperture, length, roughness and infilling and are first rated individually according to Table 2-6, and then summarized for each fracture. Except for length rating all parameters to be considered are included in the SICADA parameter table p_frac_core. According to the method description (Hakami 2020) the length rating is set to 2, corresponding to a fracture length of 3–10 m. This is a precaution since the fracture length in Forsmark generally are shorter (Fox et al. 2007).

Table 2-6. Guideline for classification of discontinuity (Bieniawski 1989).

Discontinuity length (persistence) [m]	< 6	1–3	3–10	10–20	> 20
Rating	6	4	2	1	0
Separation (aperture) [mm]	None	< 0.1	0.1–1.0	1–5	> 5
Rating	6	5	4	1	0
Roughness	Very rough	Rough	Slightly rough	Smooth	Slickensided
Rating	6	5	3	1	0
Infilling	None	Hard filling < 5 mm	Hard filling > 5 mm	Soft filling < 5 mm	Soft filling > 5 mm
Rating	6	4	2	2	0
Weathering	Unweathered	Slightly weathered	Moderately weathered	Highly weathered	Decomposed
Rating	6	5	3	1	0

The rating for roughness is determined from the two fracture parameters *roughness* and *surface* according to Table 2-7.

Table 2-7. Determination of roughness rating.

Roughness	Roughness code	Surface	Surface code	Rating
Irregular	4	Rough	1	6
	4	Smooth	2	5
	4	Slickensided	3	3
Stepped	3	Rough	1	6
	3	Smooth	2	5
	3	Slickensided	3	3
Undulating	2	Rough	1	5
	2	Smooth	2	3
	2	Slickensided	3	1
Planar	1	Rough	1	1
	1	Smooth	2	1
	1	Slickensided	3	0

The infilling rating is based on the thickness and hardness of the two most common minerals in each fracture according to Table 2-8. The mineral division into soft and hard is shown in Table 2-9.

Table 2-8. Determination of the infilling rating from thickness and mineral hardness.

Infilling thickness > 5 mm		
Mineral 1	**Mineral 2**	**Rating**
Soft	Soft	0
Soft	Hard	0
Hard	Soft	2
Hard	Hard	2
Infilling thickness < 5 mm		
Mineral 1	**Mineral 2**	**Rating**
Soft	Soft	2
Soft	Hard	2
Hard	Soft	4
Hard	Hard	4
No infilling		
Mineral 1	**Mineral 2**	**Rating**
-	-	6

Table 2-9. Division of minerals into soft and hard for KFR117–121.

Soft minerals	Hard minerals
Asphalt	Adularia
Biotite	Bleached walls
Calcite	Epidot
Chalcopyrite	No detectable mineral
Chlorite	Oxidized walls
Clay minerals	Prehnite
Hematite	Pyrite
Illite	Quartz
Iron hydroxide	Red feldspar
Laumontite	White feldspar
Muscovite	
Polished walls	
Talc	
Zeolite	

The words for weathering are not the same in the p_fract_core parameter table as used in the RMR-system (Table 2-6). The rating for weathering is determined according to Table 2-10.

Table 2-10. Determination of weathering rating.

Fracture alteration	Fracture alteration code	Rating
Fresh	6	6
Slightly altered	1	5
Moderately altered	2	3
Highly altered	3	1
Completely Altered	4	0
Gouge	5	0

After summing the sub-rating for each individual open fracture, an average of the five fractures with the lowest rating is calculated for every 5 m-interval in the borehole. For 1-m intervals with no fractures the sum is set to 30, corresponding to the highest rating for all sub-parameters in Table 2-3.

2.3.4 R5 – groundwater conditions

For RMR_{bas} characterization the rating for groundwater conditions, R5, is set to 15, corresponding to completely dry conditions.

2.3.5 RMR_{bas} value

The RMR_{bas} value is calculated as the sum of the four rating values R1, (R2+R3), R4 and R5 for each 5 m-intervals according to Equation (2-2). These values are reported and stored in SICADA.

2.3.6 Rock mass classification

Based on the resulting numerical Q_{bas} and RMR_{bas} values, the rock mass can be divided into different rock mass quality classes, Table 2-11. The rock classifications are further connected to recommendations for reinforcement.

Tabel 2-11. Rock mass classification based on Q- and RMR rating.

Total rating								
RMR								
100–81	80–61	60–41	40–21	20–0				
Very good	Good	Fair	Poor	Very poor				
Q								
> 400	400–100	100–40	40–10	10–4	4–1	1–0.1	0.1–0.01	0.01–0.001
Excellent	Extremely good	Very good	Good	Fair	Weak	Very weak	Extremely weak	Exceptionelly weak

3 Result

The result of the characterization for borehole KFR117–121 is presented in Table 3-1 to 3-5.

3.1 KFR117

The lowest Q_{bas} values in KFR117, belonging to the rock quality class *fair,* includes four 5 m-intervals. The lower values in these intervals are a result of reduced fracture strength due to smooth fracture surfaces with chlorite filling. The rest of the intervals have Q_{bas} values in the quality classes *good* or *very good*.

According to RMR_{bas} the majority of the 5 m-intervals are classified as *good*, and a few intervals as *very good*.

Table 3-1. The result of the characterization for KFR117.

Adjusted sec up	Adjusted sec low	RQD/Jn	Jr/Ja	Jw/SRF	Qbas		R1	R2 + R3	R4	R5	RMRbas	
					Value	Class					Value	Class
9	14	13.4	1.44	1	19.4	Good	14	22	13	15	64	Good
14	19	15.2	0.88	1	13.4	Good	14	24	13	15	66	Good
19	24	15.1	0.78	1	11.9	Good	13	27	13	15	68	Good
24	29	14.4	1.03	1	14.9	Good	12	26	13	15	66	Good
29	34	16.5	1.00	1	16.5	Good	14	31	15	15	75	Good
34	39	16.4	1.53	1	25.1	Good	14	30	15	15	73	Good
39	44	15.2	0.83	1	12.7	Good	13	28	15	15	71	Good
44	49	15.2	0.80	1	12.2	Good	14	27	14	15	70	Good
49	54	15.6	1.00	1	15.6	Good	13	29	15	15	72	Good
54	59	15.2	0.50	1	7.6	Fair	12	28	13	15	68	Good
59	64	16.6	1.77	1	29.3	Good	13	35	17	15	79	Good
64	69	16.2	0.75	1	12.1	Good	14	31	14	15	74	Good
69	74	15.7	0.72	1	11.3	Good	15	29	14	15	73	Good
74	79	15.5	2.73	1	42.3	Very good	16	33	21	15	85	Very good
79	84	16.2	0.62	1	10.0	Fair	16	28	14	15	73	Good
84	89	14.1	0.35	1	4.9	Fair	16	27	12	15	70	Good
89	94	31.8	1.37	1	43.4	Very good	16	31	16	15	78	Good
94	99	16.1	1.90	1	30.5	Good	14	29	16	15	74	Good
99	104	15.6	0.83	1	13.0	Good	10	25	14	15	65	Good
104	109	15.5	2.87	1	44.4	Very good	13	30	19	15	77	Good
109	114	32.4	1.82	1	58.8	Very good	12	32	18	15	77	Good
114	119	16.6	1.97	1	32.7	Good	14	33	17	15	78	Good
119	124	32.8	2.20	1	72.2	Very good	13	32	16	15	76	Good
124	129	24.4	3.50	1	85.3	Very good	12	36	24	15	87	Very good
129	134	33.3	2.88	1	96.1	Very good	12	37	24	15	88	Very good
134	139	16.7	1.87	1	31.1	Good	12	34	19	15	81	Very good
139	144	15.9	1.77	1	28.0	Good	10	30	18	15	73	Good
144	149	30.4	1.57	1	47.6	Very good	14	28	17	15	74	Good
149	154	32.5	1.23	1	40.1	Very good	13	33	15	15	76	Good
154	159	16.2	0.88	1	14.3	Good	13	31	20	15	78	Good
159	164	32.4	2.38	1	77.2	Very good	12	31	17	15	75	Good
164	169	15.7	1.70	1	26.7	Good	12	30	13	15	70	Good
169	174	15.9	0.62	1	9.8	Fair	12	30	14	15	71	Good
174	176	16.0	0.75	1	12.0	Good	12	29	14	15	70	Good

3.2 KFR118

In KFR118 the interval 65–70 m has the lowest Q_{bas} value, classified as *fair*. The value is lowered both by decreased fracture strength, due to chlorite and clay minerals, and by an increased number of fracture sets in this interval. The remaining intervals are classified as *good* or *very good*.

According to RMR_{bas} all intervals in KFR118 are classified as *good*.

Table 3-2. The result of characterization for KFR118.

Adjusted sec up	Adjusted sec low	RQD/Jn	Jr/Ja	Jw/SRF	Qbas		R1	R2 + R3	R4	R5	RMRbas	
					Value	Class					Value	Class
12.033	15	95.00	2.67	1	253.44	Extremely good	13	22	13	15	63	Good
15	20	31.33	0.90	1	28.20	Good	14	26	11	15	66	Good
20	25	31.49	1.60	1	50.38	Very good	13	30	13	15	71	Good
25	30	32.25	1.20	1	38.70	Good	12	28	12	15	67	Good
30	35	31.64	2.57	1	81.21	Very good	12	30	10	15	67	Good
35	40	30.94	0.90	1	27.85	Good	14	27	9	15	65	Good
40	45	32.54	1.60	1	52.06	Very good	16	28	11	15	70	Good
45	50	31.93	2.07	1	65.98	Very good	16	33	11	15	75	Good
50	55	32.25	1.00	1	32.25	Good	16	28	10	15	69	Good
55	60	15.53	0.77	1	11.91	Good	16	27	10	15	68	Good
60	65	32.57	0.70	1	22.80	Good	16	28	9	15	68	Good
65	70	10.41	0.93	1	9.71	Fair	15	28	11	15	69	Good
70	75	14.80	1.00	1	14.80	Good	16	26	12	15	69	Good
75	80	15.38	0.80	1	12.30	Good	16	27	11	15	69	Good
80	85	14.30	1.03	1	14.78	Good	16	27	11	15	69	Good
85	90	16.12	1.60	1	25.80	Good	15	30	12	15	72	Good
90	95	32.92	1.15	1	37.86	Good	16	30	8	15	69	Good
95	100	31.45	1.43	1	45.07	Very good	16	26	12	15	69	Good
100	105	15.28	1.13	1	17.31	Good	16	27	9	15	67	Good
105	110	14.84	1.07	1	15.83	Good	16	27	11	15	69	Good
110	115	14.92	1.50	1	22.38	Good	16	28	10	15	69	Good
115	120	10.29	1.03	1	10.63	Good	16	26	14	15	71	Good
120	125	16.20	1.30	1	21.06	Good	16	27	12	15	70	Good
125	130	33.19	1.60	1	53.10	Very good	16	30	14	15	75	Good
130	135	10.60	1.90	1	20.14	Good	16	28	12	15	71	Good
135	140	15.15	1.50	1	22.73	Good	16	27	14	15	72	Good
140	145	16.67	2.40	1	40.00	Good	16	33	14	15	78	Good
145	150	15.61	0.73	1	11.44	Good	16	27	10	15	68	Good
150	155	30.17	0.60	1	18.10	Good	16	26	5	15	62	Good
155	160	15.54	0.73	1	11.40	Good	16	27	10	15	68	Good
160	165	30.91	0.67	1	20.60	Good	15	27	7	15	64	Good
165	170	31.56	1.03	1	32.61	Good	13	27	7	15	62	Good
170	175	16.53	0.80	1	13.23	Good	12	27	9	15	63	Good
175	175.48	100.00	0.67	1	66.67	Very good	12	33	12	15	72	Good

3.3 KFR119

The lowest Q_{bas} value for KFR119 is in the interval 100–105 m, classified as *fair*. The lower value is mainly due to reduced fracture strength caused by planar surfaces and chlorite filling. The rest of the intervals are evenly distributed between the Q_{bas} classification *good* and *very good*.

Except for one *very good* interval, all intervals in KFR119 are classified as *good* according to RMR_{bas}.

Table 3-3. the result of the characterization of KFR119.

Adjusted sec up	Adjusted sec low	RQD/Jn	Jr/Ja	Jw/SRF	Qbas		R1	R2 + R3	R4	R5	RMRbas	
					Value	Class					Value	Class
9	10	32.00	1.50	1	48.00	Very good	12	27	12	15	66	Good
10	15	31.73	1.28	1	40.75	Very good	12	30	9	15	66	Good
15	20	32.71	2.67	1	87.23	Very good	12	35	14	15	76	Good
20	25	16.10	0.75	1	12.07	Good	12	30	12	15	69	Good
25	30	32.19	2.05	1	65.98	Very good	13	33	18	15	79	Good
30	35	32.77	2.15	1	70.45	Very good	13	33	13	15	74	Good
35	40	16.03	0.82	1	13.09	Good	12	30	14	15	71	Good
40	45	16.50	1.69	1	27.91	Good	14	33	14	15	76	Good
45	50	32.78	0.95	1	31.14	Good	14	30	12	15	71	Good
50	55	32.48	2.77	1	89.86	Very good	14	33	14	15	76	Good
55	60	32.64	2.57	1	83.77	Very good	13	33	12	15	73	Good
60	65	30.67	0.75	1	23.01	Good	13	27	14	15	69	Good
65	70	33.05	3.23	1	106.85	Extremely good	12	33	11	15	71	Good
70	75	16.21	3.50	1	56.71	Very good	13	35	14	15	77	Good
75	80	33.33	1.95	1	65.00	Very good	11	33	14	15	73	Good
80	85	31.93	1.00	1	31.93	Good	13	30	12	15	70	Good
85	90	16.56	1.15	1	19.04	Good	13	30	12	15	70	Good
90	95	33.33	1.77	1	58.89	Very good	13	35	14	15	77	Good
95	100	31.87	1.70	1	54.18	Very good	14	28	14	15	71	Good
100	105	15.87	0.50	1	7.97	Fair	13	28	12	15	68	Good
105	110	33.01	2.68	1	88.58	Very good	12	33	14	15	74	Good
110	115	16.40	1.10	1	18.04	Good	12	33	14	15	74	Good
115	120	16.67	3.55	1	59.16	Very good	12	35	14	15	76	Good
120	125	16.64	1.20	1	19.97	Good	13	33	14	15	75	Good
125	130	16.67	1.05	1	17.50	Good	13	35	14	15	77	Good
130	135	33.28	1.77	1	58.79	Very good	13	33	14	15	75	Good
135	140	33.33	1.92	1	63.89	Very good	12	33	14	15	74	Good
140	145	16.06	2.02	1	32.39	Good	13	33	14	15	75	Good
145	150	16.16	1.98	1	32.06	Good	13	30	12	15	70	Good
150	155	16.39	3.33	1	54.51	Very good	12	35	14	15	76	Good
155	160	15.98	2.65	1	42.34	Very good	12	30	14	15	71	Good
160	165	16.54	0.90	1	14.89	Good	12	33	14	15	74	Good
165	170	33.33	0.50	1	16.73	Good	14	33	14	15	76	Good
170	175	16.24	1.84	1	29.91	Good	13	30	14	15	72	Good
175	176	33.33	1.00	1	33.33	Good	12	40	16	15	83	Very good

3.4 KFR120

The 5 m-intervals in KFR120 are evenly distributed between the rock quality classes *good* and *very good* for Q_{bas}.

According to RMR_{bas}, one interval in KFR120 is classified as *fair* equaling the limit to *good,* in which quality class the additional intervals are found.

Table 3-4. The result of the characterization of KFR120.

Adjusted sec up	Adjusted sec low	RQD/Jn	Jr/Ja	Jw/SRF	Qbas		R1	R2 + R3	R4	R5	RMRbas	
					Value	Class					Value	Class
12.004	17	29.27	0.60	1	17.56	Good	14	24	8	15	61	Good
17	22	33.29	1.77	1	58.92	Very good	13	33	12	15	73	Good
22	27	14.29	1.93	1	27.57	Good	13	27	7	15	62	Good
27	32	31.24	2.42	1	75.60	Very good	13	30	12	15	70	Good
32	37	30.21	1.55	1	46.83	Very good	13	26	12	15	66	Good
37	42	30.03	0.60	1	18.02	Good	13	27	11	15	66	Good
42	47	16.28	1.60	1	26.05	Good	13	33	13	15	74	Good
47	52	32.46	1.40	1	45.44	Very good	14	33	11	15	73	Good
52	57	16.19	1.60	1	25.90	Good	14	30	13	15	72	Good
57	62	29.98	0.90	1	26.98	Good	15	27	11	15	68	Good
62	67	32.45	1.50	1	48.67	Very good	16	30	13	15	74	Good
67	72	31.19	1.30	1	40.55	Very good	13	28	14	15	70	Good
72	77	31.93	2.20	1	70.25	Very good	12	28	16	15	71	Good
77	82	30.29	1.02	1	30.90	Good	10	24	11	15	60	Fair
82	87	32.82	1.90	1	62.36	Very good	13	30	12	15	70	Good
87	92	32.57	1.00	1	32.57	Good	12	30	14	15	71	Good
92	97	30.83	1.70	1	52.42	Very good	15	27	9	15	66	Good
97	102	32.33	1.80	1	58.19	Very good	15	33	14	15	77	Good
102	107	32.41	2.67	1	86.53	Very good	12	30	13	15	70	Good
107	112	31.17	1.27	1	39.59	Good	12	28	9	15	64	Good
112	117	31.67	1.80	1	57.01	Very good	12	30	13	15	70	Good
117	122	32.80	2.00	1	65.60	Very good	12	28	11	15	66	Good
122	127	30.99	1.55	1	48.04	Very good	12	30	12	15	69	Good
127	132	33.17	1.60	1	53.07	Very good	12	30	11	15	68	Good
132	137	15.86	1.40	1	22.20	Good	12	28	14	15	69	Good
137	142	15.80	0.87	1	13.75	Good	15	27	10	15	67	Good
142	147	16.23	1.05	1	17.05	Good	11	30	11	15	67	Good
147	152	31.15	1.87	1	58.26	Very good	10	28	11	15	64	Good
152	157	31.90	1.92	1	61.25	Very good	10	33	12	15	70	Good
157	162	30.67	0.75	1	23.01	Good	10	28	12	15	65	Good
162	167	29.48	2.07	1	61.02	Very good	13	27	14	15	69	Good
167	172	15.71	1.00	1	15.71	Good	12	28	12	15	67	Good
172	176.88	16.48	1.60	1	26.36	Good	12	33	14	15	74	Good

3.5 KFR121

The lowest Q_{bas} values in KFR121 includes ten 5 m-intervals with the rock quality class *fair*. Four of these forms a continuous interval at 90–110 m. The lower values in this interval are mainly due to reduced fracture strength, but also a slightly higher fracture frequency resulting in a lowered RQD.

The other Q_{bas} intervals are mainly classified as *good*, but there are also intervals classified as *very good* to *excellent.*

According to RMR_{bas} only one 5 m-interval is classified as *fair.* The rest of the intervals are mainly classified as *good* and a few intervals as *very good*.

Table 3-5. The result of the characterization of KFR121.

Adjusted sec up	Adjusted sec low	RQD/Jn	Jr/Ja	Jw/SRF	Qbas		R1	R2 + R3	R4	R5	RMRbas	
					Value	Class					Value	Class
41.132	45	16.67	0.58	1	9.72	Fair	14	30	14	15	73	Good
45	50	16.18	1.12	1	18.07	Good	14	30	14	15	73	Good
50	55	16.46	1.40	1	23.04	Good	14	30	17	15	76	Good
55	60	16.07	0.93	1	15.01	Good	13	28	17	15	73	Good
60	65	16.07	0.93	1	15.01	Good	14	26	15	15	69	Good
65	70	16.29	1.52	1	24.70	Good	14	30	16	15	75	Good
70	75	33.00	4.40	1	145.19	Extremely good	13	35	25	15	88	Very good
75	80	16.26	1.92	1	31.16	Good	12	33	19	15	79	Good
80	85	16.67	0.93	1	15.43	Good	11	33	16	15	75	Good
85	90	15.12	1.08	1	16.38	Good	12	28	16	15	71	Good
90	95	14.31	0.43	1	6.09	Fair	13	26	12	15	66	Good
95	100	13.83	0.53	1	7.27	Fair	14	24	13	15	66	Good
100	105	15.53	0.58	1	8.94	Fair	14	28	14	15	71	Good
105	110	15.25	0.55	1	8.39	Fair	14	27	14	15	70	Good
110	115	16.05	0.67	1	10.72	Good	13	30	14	15	73	Good
115	120	16.16	1.20	1	19.39	Good	12	33	15	15	76	Good
120	125	16.51	2.40	1	39.62	Good	12	33	17	15	78	Good
125	130	15.70	0.48	1	7.47	Fair	12	28	14	15	69	Good
130	135	30.94	1.47	1	45.38	Very good	14	30	18	15	76	Good
135	140	32.79	2.52	1	82.55	Very good	13	35	20	15	84	Very good
140	145	16.57	0.70	1	11.60	Good	13	33	15	15	76	Good
145	150	16.67	1.70	1	28.34	Good	14	33	17	15	79	Good
150	155	32.18	0.93	1	30.06	Good	13	33	16	15	77	Good
155	160	16.19	2.20	1	35.64	Good	13	30	19	15	78	Good
160	165	16.04	1.08	1	17.26	Good	14	33	17	15	78	Good
165	170	15.52	0.58	1	9.07	Fair	13	30	14	15	72	Good
170	175	15.89	2.12	1	33.64	Good	13	30	19	15	77	Good
175	180	32.82	1.89	1	62.12	Very good	11	33	19	15	78	Good
180	185	16.08	0.73	1	11.80	Good	13	28	15	15	71	Good
185	190	16.45	0.75	1	12.34	Good	13	30	15	15	73	Good
190	195	16.56	0.78	1	12.85	Good	12	30	15	15	72	Good
195	200	15.87	1.78	1	28.18	Good	11	30	19	15	75	Good
200	205	16.13	2.72	1	43.82	Very good	13	33	21	15	82	Very good
205	210	32.15	1.17	1	37.50	Good	13	30	16	15	73	Good
210	215	15.94	1.30	1	20.72	Good	12	30	16	15	73	Good
215	220	16.14	0.93	1	15.06	Good	12	30	16	15	74	Good
220	225	16.35	0.90	1	14.72	Good	12	33	16	15	76	Good
225	230	14.01	0.49	1	6.90	Fair	14	24	14	15	66	Good
230	235	16.02	1.67	1	26.69	Good	13	30	18	15	76	Good
235	240	16.15	0.75	1	12.11	Good	13	30	15	15	73	Good
240	245	16.12	1.25	1	20.15	Good	15	33	15	15	79	Good
245	250	100.00	4.47	1	446.64	Excellent	14	40	27	15	96	Very good
250	255	32.85	3.73	1	122.60	Extremely good	12	35	24	15	86	Very good

Table 3-5. Continued.

Adjusted sec up	Adjusted sec low	RQD/Jn	Jr/Ja	Jw/SRF	Qbas		R1	R2 + R3	R4	R5	RMRbas	
					Value	Class					Value	Class
255	260	100.00	2.83	1	283.32	Extremely good	12	35	23	15	85	Very good
260	265	14.98	0.60	1	8.99	Fair	10	28	14	15	67	Good
265	270	16.40	1.30	1	21.32	Good	10	30	16	15	71	Good
270	275	15.57	1.08	1	16.87	Good	11	30	15	15	72	Good
275	280	15.24	1.62	1	24.63	Good	14	28	18	15	75	Good
280	285	16.45	1.00	1	16.45	Good	14	33	16	15	78	Good
285	290	15.55	0.83	1	12.97	Good	13	24	14	15	66	Good
290	295	13.78	0.90	1	12.40	Good	11	26	14	15	66	Good
295	300	15.80	1.23	1	19.48	Good	12	27	16	15	71	Good
300	305	14.07	0.85	1	11.96	Good	14	24	15	15	68	Good
305	310	32.45	0.52	1	16.76	Good	14	30	14	15	72	Good
310	315	15.89	0.98	1	15.51	Good	14	28	15	15	72	Good
315	320	16.02	1.35	1	21.63	Good	13	30	17	15	75	Good
320	325	14.60	0.77	1	11.19	Good	13	24	15	15	67	Good
325	330	10.91	0.59	1	6.38	Fair	12	16	8	15	52	Fair rock
330	335	31.77	0.85	1	27.01	Good	12	28	14	15	70	Good
335	340	15.98	1.63	1	26.10	Good	12	33	17	15	78	Good
340	345	16.67	1.80	1	30.00	Good	12	33	18	15	79	Good
345	350	33.33	1.82	1	60.55	Very good	12	35	18	15	80	Good
350	355	33.33	2.47	1	82.22	Very good	12	35	19	15	81	Very good
355	360	33.33	3.70	1	123.33	Extremely good	12	35	24	15	87	Very good
360	362.53	33.33	2.44	1	81.48	Very good	12	35	25	15	87	Very good

4 Delivery and storage of results

Executed work and results are quality assured and reported according to the SKB instruction for data delivery "Hantering av primärdata" (document ID 1202022).

An excel sheet Data Import Template is used for delivery of the results to SICADA. The activity type identification code is *RM002 – Determination of* Q_{bas} *and* RMR_{bas}.

The delivery to SKB also includes the original excel sheets with characterization and calculations for each borehole KFR117–121.

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