



REPORT

Drainage Åknes

DATA REPORT CORE LOGGING KH-01-2018

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REV.NO. 0 / 2019-02-11

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for NGI

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Summary

KH-01-18 is a core drilled bore hole at the west flank in the Åknes rock slope. The bore hole is 222.6 meter deep, and was core drilled during July to August 2018. Geodrilling AS performed the core drilling on assignment from Norwegian Water- and Energy directorate (NVE). Lise Tønset (NTNU) and Henrik Langeland performed engineering geological core logging in November-December 2018.

The rock type registered in KH-01-2018 is gneiss with variation in grain size and colour according to classification from ISO 14689.

The core logging shows that the core is intersected with crushed zones in the upper 50-60 m. In this section also 2 intervals with core loss are registered. From 60 m to about 160 m depth there is no presence of crushed zones >10 cm, however RQD and fractures/meter (FFm) values are varying. From about 160 m to end of bore hole the rock mass is considered solid with a massive character. No crushed zones are registered and the rock mass is generally considered good, evaluating RQD- and FFm values.

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Review and reference page

1 Introduction

KH-01-18 is a core drilled bore hole at the west flank in the Åknes rock slope. The bore hole is 222.6 meter deep, and was drilled during July to August 2018. Geodrilling AS performed the core drilling on assignment from Norwegian Water- and Energy directorate (NVE). Lise Tønset (master student NTNU) and Henrik Langeland performed engineering geological core logging in 2018.

The core drilling is carried out to investigate the subsurface in the Åknes rock slope, e.g. degree of fracturing, weak zones, lithological composition. In addition to the core logging, tests will be performed on selected core samples, e.g. to evaluate lithology, mineral composition and strength parameters.

This report gives an overview of the core logging of KH-01-18, method for core logging, and results. All ancillary data are organized in appendices:

Appendix A: Drilling report from Geodrilling

Appendix B: LogPlot

Appendix C: Pictures of cores

2 Core drilling KH-01-18

KH-01-18 is a vertical borehole, located in the west flank of Åknes rock slope, 593 meters above sea level (Figure 1). Drilling depth is 222.6 m. Steel casing is placed down to -1.5 m. Core length, logged length, is 222.6 meter.

The core drilling has been performed with Diamec U-6 APC rig, with HQ diamond tipped core bit, giving a borehole diameter of about 96 mm and a core diameter of about 63.5 mm. Geodrilling AS report from core drilling is given in Appendix A.

Core logging sheets (Logplot), with results from core logging is shown in Appendix B, and pictures of the cores is shown in Appendix C.

After drilling, several water pressure tests (Lugeon test) was performed with double packer setup. The borehole has also been logged with optical televiewer, flowmeter and geophysics after core extraction.

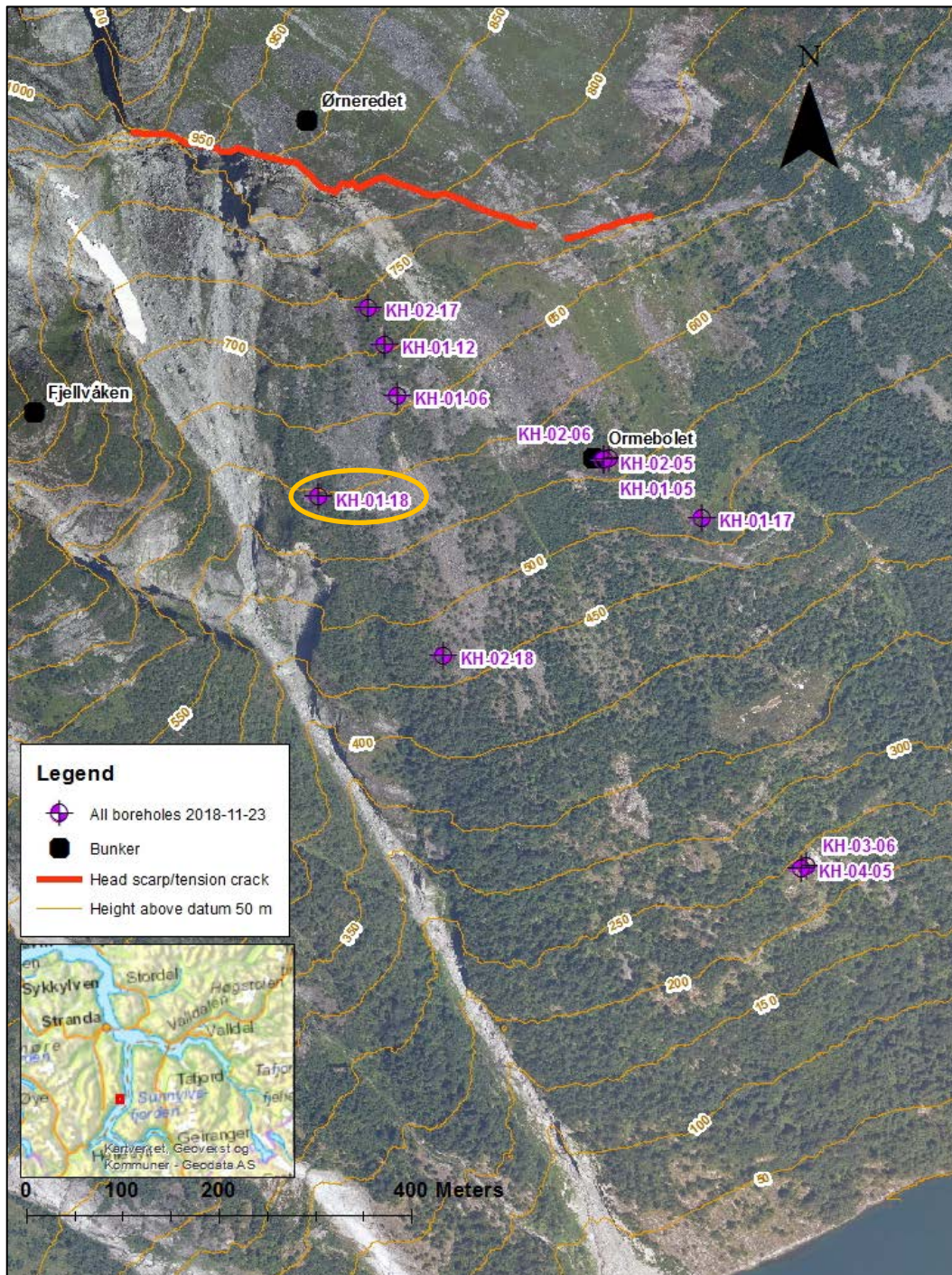


Figure 1. Overview of the Åknes unstable rock slope with bore hole locations, including bore hole KH-01-18 in yellow ellipse.

3 Brief regional geological description

The geology at the Åknes rock slope is thoroughly described, by field mapping and core logging [1] [2] [3] [4].

Åknes is situated in the Western Gneiss Region (WGR), located west of the Caledonian thrust nappe [5]. WGR consists of autochthon Precambrian rocks, mainly granitic- to dioritic gneiss, in some places migmatitic [1]. These rocks are about 1850-1500 million years old, and contain features such as bands with mica rich gneiss and amphibolite [6].

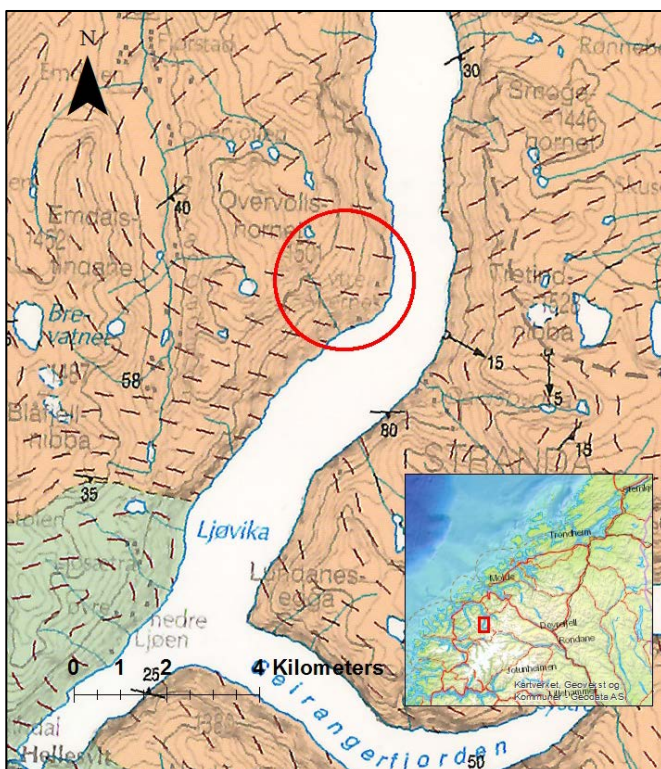


Figure 2. Excerpt of geological map 1:250 000 for the Åknes rock slope (red circle). Light orange color is mapped as: "Gneiss, not grouped, mainly quartzdioritic to granitic, in some places migmatitic" and light green colour is mapped as: "Mica gneiss, quartz mica gneiss, some garnet amphibolite, garnet mica schist, meta-arkose and anorthosite" [7].

The geological map from the area shows that at the Åknes rock slope the bedrock is defined as "Gneiss, not grouped, mainly quartzdioritic to granitic, in some places migmatitic" [7]. The map also shows that just west-southwest of the Åknes rock slope the bedrock is mapped as (2): "Mica gneiss, quartz mica gneiss, some garnet amphibolite, garnet mica schist, meta-arkose and anorthosite".

4 Method

The core logging contain geological description of the core according to ISO 14689:2017 [8], registration of core loss, crushed core, fracture frequency and Q method parameters; RQD (Rock Quality Designation), J_r (joint roughness number) and J_a (joint alteration number). The core is not oriented, but the borehole have been logged with televiewer, and therefore an overview of joint sets and dip/dip-direction are reported by the Geological Survey of Norway (NGU).

4.1 Q-parameters

The Q-method is a classification system for rock mass in relation to stability of underground excavations such as tunnels and caverns [9]. By determining the 6 Q-parameters one can decide the Q-value for the rock mass:

$$Q = \frac{RQD}{J_n} + \frac{J_r}{J_a} + \frac{J_w}{SRF} \quad (1)$$

where:

- 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
- SRF = Stress reduction factor

Evaluation of the 6 parameters is described by NGI [9]. The Q-value can vary from 0.001 (exceptionally poor) to 1000 (exceptionally good), where values above 10 is equivalent to good rock mass quality. By core logging one can determine the parameters RQD, J_n (if cores are oriented), J_r , og J_a , and by this determine the rock mass properties. The parameters J_w (Joint water reduction factor) and SRF (Stress reduction factor) cannot be determined from cores, and therefore a Q-value from core logging will represent a Q-value where J_w and SRF are not accounted for.

There is also uncertainty connected to J_r - and J_a values in core logging. By logging a 64 mm core, only a small excerpt of the joint is visible. A J_r value determined for a joint in the core is not necessary representative for the bulk scale joint. This is equivalent for the J_a value. Joint filling and -coating can vary along the joint, and drilling can affect the remaining joint infill after core extraction.

J_n -values are not registered during logging, as the core is not oriented. However, the televiewer analysis will describe joint sets and dip/dip-direction of joints.

4.2 Fracture frequency and crushed core

The fracture frequency (fractures/meter, FFm) is evaluated for every meter, based on the number of natural joints, inclusive crushed zones. For crushed zones an FFm value between 2 and 25 is given, counting one joint for every 4 cm of crushed zone in addition to joint in the start and end of crushed zone. Minimum FFm value for crushed zone would then be 2 if the crushed zone is shorter than 4 cm. Maximum FFm value would be 25 for 100 cm core, which implies that the entire core is a crushed zone.

However, deciding FFm from core logging is connected to uncertainty due to the presence of artificial joints caused by drilling and handling of cores in the wireline system. It's sometimes difficult to determine a natural joint from an artificial joint, and the result would be an overestimation of joints in the core logging. Having the televiewer analysis in addition to the core logging makes it possible to compare the joint frequency.

The drillers are instructed to mark joints which they certainly know are artificial, with a permanent marker. However, the marking can disappear or artificial joints could not be marked by drillers due to difficulty identifying such joints. The joints interpreted by the logger to be artificial, but not marked with a permanent marker, is marked with X as J_r and J_a value. In the following J_r and J_a overview (chapter 5.2.2) joint no. is set as 0.

4.3 Core loss

Core loss is evaluated for every meter, based on missing core sections. In order for this to be registered correct, the drillers have to mark core loss in the boxes.

5 Results

5.1 Overview borehole

A simplified overview of RQD, average RQD every 10 meters, FFm, average FFm every 10 meters, crushed zone >10 cm and core loss distribution in the borehole is shown in Figure 3.

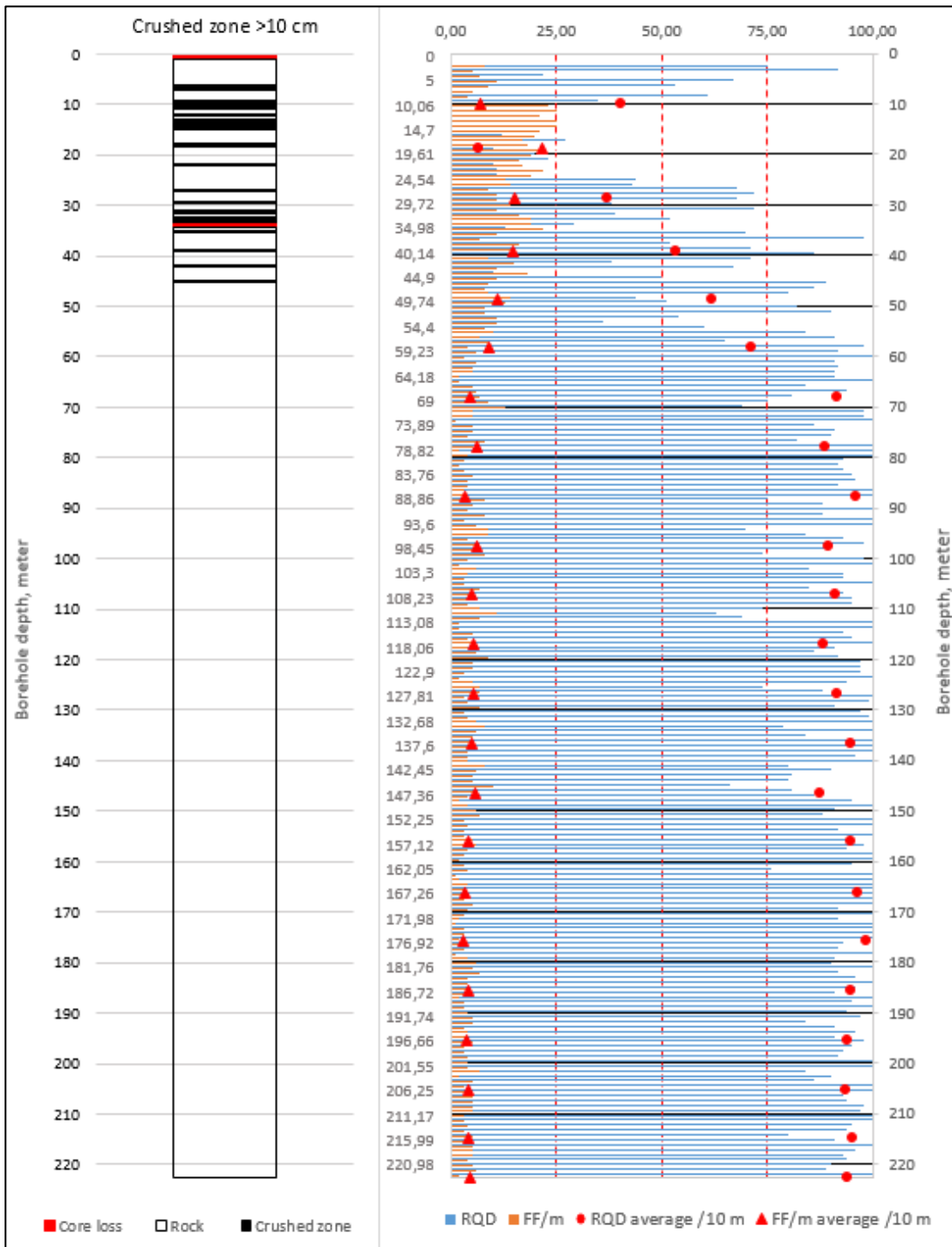


Figure 3. Simplified overview of RQD, average RQD every 10 meters, FFm, average FFm every 10 meters, crushed zone >10 cm and core loss distribution in KH-01-18.

5.2 Logging parameters

5.2.1 RQD and FFm

The upper 68 m of the bore hole is intersected with crushed zones > 10 cm, and 2 sections with core loss are registered. The average RQD value from 0 m to 68 m is 52 and the FFm value is 11.8 (Figure 3).

From 68 m down to 156 m the presence of crushed zones > 10 cm are absent, however the RQD and FFm values are varying, with some fractured sections. The average RQD value from 68 m to 156 m is 91 and the FFm value is 5 (Figure 3).

From 156 m to the end of borehole the rock mass is considered solid with a rather massive character. The average RQD value from 156 m to 222.6 m is 95 and the FFm value is 3.8 (Figure 3).

5.2.2 J_r , J_a

J_r and J_a is registered for every joint, besides in the crushed zones where this is practical impossible. Figure 4 shows the frequency of J_r and J_a , from a-p and X. The J_r and J_a categories are given values according to NGI [9] and X describe artificial joints. J_a range from a to p according to NGI [9], but only values from a to g are registered.

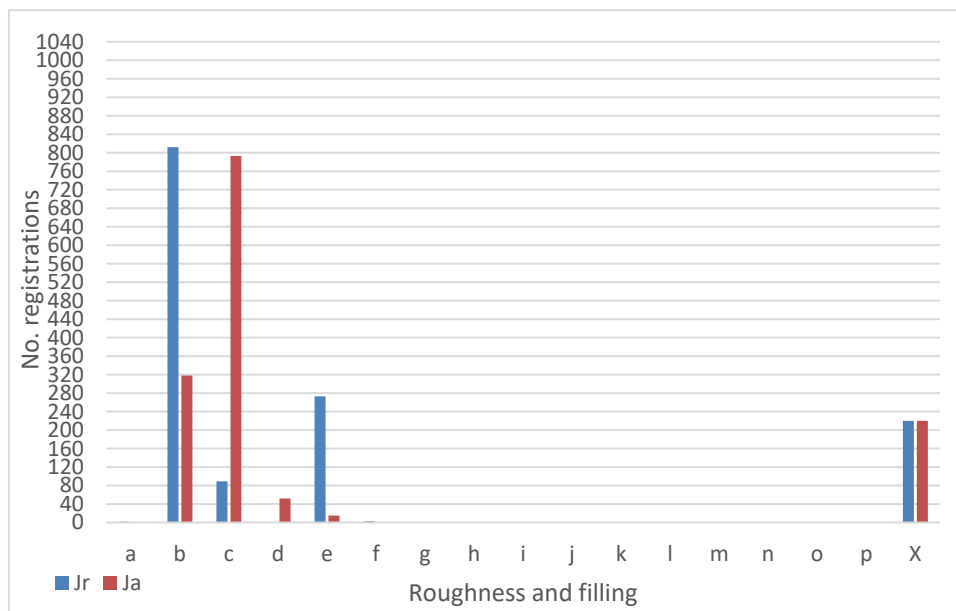


Figure 4. Histogram representing the frequency of J_r and J_a values for the entire borehole. J_a values can be determined in the range from a to p [9], however only values from a to g was registered.

The histogram show that J_r categories of b (rough or irregular, undulating) and e (rough, irregular, planar) are dominating, and very few smooth planar (f) and none slickensided undulating (d) categories are registered. The dominating J_a categories are b (unaltered joint walls, surface staining only) and c (slightly altered joint walls. Non-softening mineral coatings; sandy particles, clay free disintegrated rock, etc.). However some joints are registered with coating or infilling (d, e) and one joint is registered with category m (zones or bands of clay, disintegrated or crushed rock, swelling clay. J_a depends on percent of swelling clay-size particles.).

The J_r and J_a categories are given values according to NGI [9]. Figure 5 and Figure 6 show distribution of these values in relation to borehole depth. J_r value 1 represent smooth and planar joints, and J_a values 3, 4 and 8 represent coating or infill on joints. I.e. joints registered with J_r value 1 and J_a value 3, 4 and 8 will probably represent low friction joints.

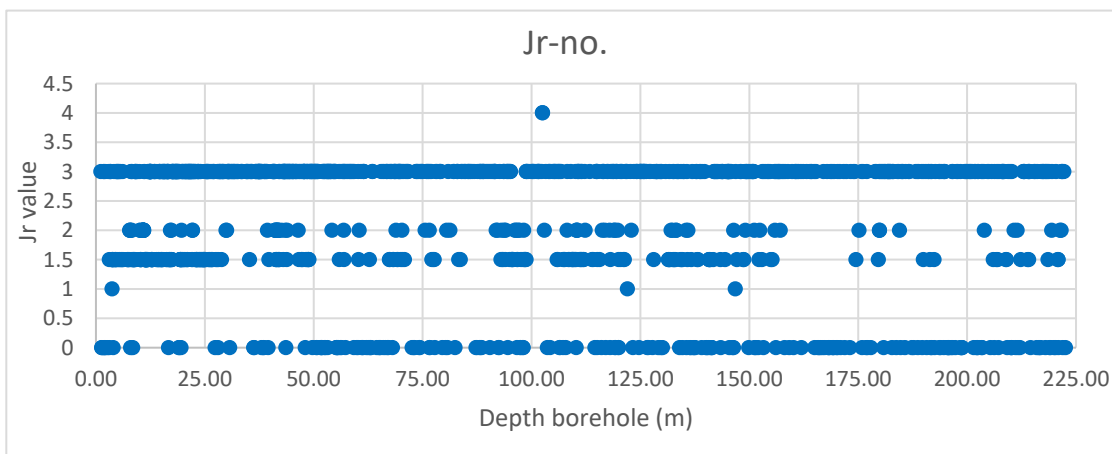


Figure 5. J_r values on joints in relation to borehole depth.

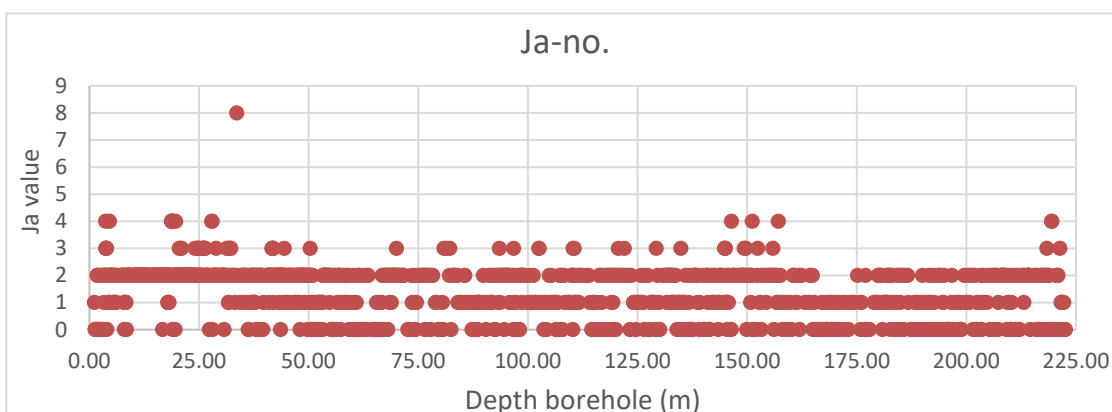


Figure 6. J_a values on joints in relation to borehole depth.

The zone registered from 33.62-34.5 consist of crushed zone with disintegrated rock and silt/clay from 33.6-33.72 and core loss from 33.72-34.5. The core drilling managed to extract this section with intact clay intersecting the crushed zone (Figure 7).



Figure 7. Zone with clay and crushed rock registered at 33.6-33.72 m. Subsequent to the crushed zone, 0.78 m with core loss is registered.

5.3 Description of the rock mass

Borehole KH-01-2018 is located in an area, which according to NGU, consists of gneiss [7]. The rock type registered in KH-01-2018 is gneiss with variation in grain size and colour [8]. ISO [8] terms foliated metamorphic rock types as Gneiss, Schist and Slate for coarse-, medium- and fine grain size respectively. It is decided to classify the entire borehole as Gneiss, but with specification of the different grain size and colour (Table 2 and Appendix B).

Table 1. Description of KH-01-2018 rock type according to ISO 14689:2017 [8].

Identification	Core logging
Genetic group	Metamorphic
Structure	Foliated
Grain size	Coarse-fine
Mineralogical composition by visual inspection	Feldspar, quartz, mica

Table 2. Overview of evaluated grain size and colour in KH-01-18.

From	To	Length	Grain size	Colour	Rock Type
0,00	1,16	1,16	Core loss		
1,16	3,77	2,61	Coarse	Grey, white, pink. Light greyish and pinkish	Gneiss
3,77	3,91	0,14	Fine		
3,91	9	5,09	Coarse	Grey, white, pink. Light greyish and pinkish	
9,00	18,19	9,19	Medium-Coarse	Dark grey-brown, section with dark grey and pink	
18,19	28,71	10,52	Fine-Medium	Dark black/brown/grey. Some pink bands	
28,71	33,72	5,01	Fine-Medium	Dark black/grey	

Table 3. Table 2 continues.

From	To	Length	Grain size	Colour	Rock Type
33,72	34,50	0,78	Core loss		
34,50	39,16	4,66	Medium-Coarse	Light to dark grey, light pink bands	Gneiss
39,16	46,8	7,64	Medium-Coarse	Grey colour in general, varying from light pinkish	
46,80	48,77	1,97	Fine-Medium	Dark black (with high mica content)	
48,77	58,32	9,55	Medium-Coarse	Dark grey to light grey. Sections with pink bands/white bands	
58,32	71	12,68	Medium-Coarse	Light grey to pink	
71,00	77,84	6,84	Fine	Dark black to dark greenish	
77,84	83,76	5,92	Medium	Dark grey to black, with some quartz bands	
83,76	91,7	7,94	Medium	Dark grey to black	
91,70	95,58	3,88	Coarse	Dark grey	
95,58	99,47	3,89	Medium-Fine	Black to dark grey	
99,47	107,3	7,83	Medium	Dark grey	
107,30	115,8	8,50	Medium-Coarse	Dark grey to black (when mica rich)	
115,80	122,9	7,10	Medium	Dark grey to black	
122,90	130,81	7,91	Medium	Dark grey	
130,81	138,58	7,77	Medium	Dark, black sporadic green/grey	
138,58	145,01	6,43	Medium	Dark grey	
145,01	148,34	3,33	Medium	Dark grey to black	
148,34	154,22	5,88	Coarse	Dark grey to grey	
154,22	158,1	3,88	Coarse-Medium	Greyish with dark mica rich bonds and light quartz rich bonds	

From	To	Length	Grain size	Colour	Rock Type
158,10	166,03	7,93	Medium	Grey with some light quartz bands	
166,03	171,98	5,95	Coarse	Grey with light bonds of quartz	
171,98	173,9	1,92	Medium	Dark grey to black greenish	
173,90	147,5	-26,40	Medium	Dark, greenish	
147,50	181,85	34,35	Medium-Coarse	Greyish with light quartz bands	
181,85	185,74	3,89	Coarse	Grey with quartz bonds	
185,74	187,72	1,98	Medium-Fine	Black to greenish	
187,72	189,71	1,99	Coarse	Grey with white quartz bands	
189,71	197,86	8,15	Coarse	Grey with light/white bonds of quartz	

Table 4. Table 2 continues.

From	To	Length	Grain size	Colour	Rock Type
197,86	205,37	7,51	Medium-Coarse	Greyish with light bands of quartz and feldspar	Gneiss
205,37	206,25	0,88	Coarse	Grey with light/white bands of quartz	
206,25	207,97	1,72	Medium-Fine	Dark black to greenish	
207,97	213,13	5,16	Coarse	Grey with light/white bands of quartz	
213,13	219,2	6,07	Coarse	Grey, light/white quartz bonds	
219,20	220,18	0,98	Medium-Fine	Dark black, greenish	
220,18	222,6	2,42	Medium-Coarse	Dark grey -light grey with quartz and feldspar bands	

5.3.1 Gneiss, coarse grained

Example of a coarse grained rock, with colour grey with light bonds of quartz is shown in Figure 8.



Figure 8. Core box 43, ca. 167.75-168.25 meter.

5.3.2 Gneiss, medium to fine grained

Example of a medium- to fine grained rock, with colour black to dark grey is shown in Figure 9.

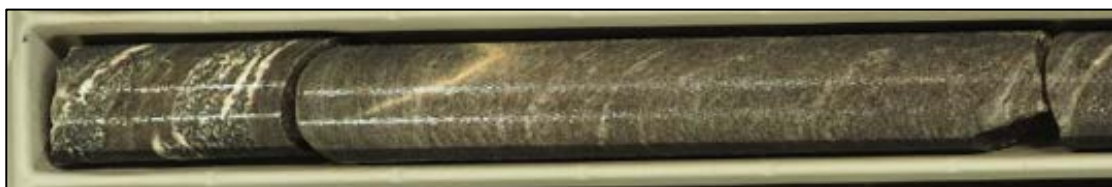


Figure 9. Core box 25, ca. 97.57-98.07 meter.

5.3.3 Gneiss, fine grained

Example of a fine grained rock, with colour dark grey-black to dark greenish is shown in Figure 10.



Figure 10. Core box 19, ca. 73.39-73.89 meters.

6 Reference

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Appendix A


GEODRILLING, REGISTERED DRILLING DATA KH-01-2018


Contents

A1	Geodrilling, Registered drilling data KH-01-2018	2
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A1 Geodrilling, Registered drilling data KH-01-2018

GEO DRILLING AS		REGISTRERING BOREDATA					SIDE 1		GEO DRILLING	
PROSJEKT: P - 170518		STED: Åknes			HULL-NR: BH - 01 - 18		KRONE: HQ	DATO: Juli-August	MASKIN: Diamec U-6 APC	FALL/RETNING: Lodd
FRA BOREDYP	TIL BOREDYP	KJERNE LENGDE	ROTASJON RPM	MATEKRAFT KILO	PENETRERING ca CM/MIN	Mottrykk Spyl.vann Bar	FARVE SPYLEVANN	KOMMENTAR		
0,00	1,50	0,30	450	1500-2000	4-8	8-10		Casing til 1,50 meter Fjell fra 1,20 meter		
1,50	1,80	0,30	700	1400-1700	5-8	0	Lys grå	Hardt dagfjell		
1,80	2,00	0,20	700	1600-1800	3-6	0-3	Lys grå			
2,00	2,70	0,70	700	2200-2800	0-4	0-3	Lys grå	Hardt		
2,70	3,60	0,90	700	2200-2500	3-10	0-3				
3,60	4,40	0,80	700	1800-2300	5-10	0-3		Oppsprukket og hardt		
4,40	5,80	1,40	700	2200-2600	8-16	0-3				
5,80	7,30	1,50	700	1500-2000	5-15	0-3		Går igjennom dårlige soner		
7,30	8,40	1,10	700	2000-2400	5-10	0-3				
8,40	8,90	0,50	700	2000-2500	8-11	0-3		Oppsprukket		
8,90	10,80	1,90	620	800-1500	10-16	0-3				
10,80	11,90	1,10	620	700-1300	15	0-3		OK fjell, horisontal lagdeling		
11,90	14,90	3,00	620	900-1100	15	0-3	Lys grå			
14,90	17,90	3,00	600	900-1100	15	0-3	Lys grå	OK fjell, horisontal lagdeling		
17,90	20,90	3,00	600	900-1200	15	0-3				
20,90	22,00	1,10	600	700-1500	15	0-3		Oppsprukket		
22,00	23,40	1,40	600	700-1400	15	0-3				
23,40	25,00	1,60	600	800-1500	15	0-3		Oppsprukket		
25,00	26,60	1,60	600	900-1500	15	0-3				
26,60	28,60	2,00	600	700-1300	15	0-3		Oppsprukket		
28,60	29,90	1,30	600	800-1500	15	0-3				
29,90	31,20	1,30	600	600-1100	15	0-3				
31,20	32,50	1,30	600	800-1000	15	0-3		Ok fjell		
32,50	34,10	1,60	600	0-1200	15	0-3		Dårlig sone, 33,60 - 34,10 meter, sand og leire		
34,10	34,30	0,20	600	100-300	15	0-3				
34,30	35,90	1,60	600	400-700	15	3-5				
35,90	37,00	1,10	700	1000-2000	15	4		Ok fjell		
37,00	38,90	1,90	700	1100-2100	12-14	3				
38,90	41,90	3,00	650	1200-2300	13-15	5-6	Lys grå	OK, noe sprukket		
41,90	42,60	0,70	650	1200-2400	13-15	4-5				
42,60	44,90	2,30	650	1200-2400	12	4-5	Grått	OK, noe sprukket		
SUM	44,90	43,70								

GEO DRILLING AS		REGISTRERING BOREDATA					SIDE 2			
PROSJEKT: P - 170518		STED: Åknes			HULL-NR: BH - 01 - 18		KRONE: HQ	DATO: August	MASKIN: Diamec U-6 APC	FALL/RETNING: Lodd
FRA BOREDYP	TIL BOREDYP	KJERNE LENGDE	ROTASJON RPM	MATEKRAFT KILO	PENETRERING ca CM/MIN	Mottrykk Spyl.vann Bar	FARVE SPYLEVANN	KOMMENTAR		
44,90	46,00	1,10	650	1200-2600	10	4-5	Grått	Oppsprukket		
46,00	47,90	1,90	680	1500-2000	15	4-5				
47,90	50,90	3,00	650	1500-2200	12-15	5-6	Grått	Oppsprukket		
50,90	53,20	2,30	650	1500-2300	10-13	4-5				
53,20	53,90	0,70	650	1600-2400	13	4-5	Grått	Oppsprukket		
53,90	54,40	0,50	650	1600-2000	13	4-5				
54,40	56,90	2,50	650	1600-2500	13	4-5	Grått	Oppsprukket		
56,90	59,40	2,50	650	1600-2700	10-13	4-5				
59,40	59,90	0,50	650	1700-2800	8-10	4-5	Grått	Oppsprukket		
59,90	60,90	1,00	650	1800-2700	10-12	4-5				
60,90	61,00	0,10	650	1800-2700	10	4-5	Grått	Bra fjell		
61,00	62,10	1,10	650	1800-2700	13	4-5				
62,10	62,50	0,40	650	1800-2700	13	4-5	Grått	Bra fjell		
62,50	62,90	0,40	650	1600-2500	13	4-5				
62,90	63,10	0,20	650	1600-2700	10	4-5	Grått	Bra fjell		
63,10	65,50	2,40	650	1800-2800	6-10	4-5				
65,50	65,90	0,40	650	2000	10-12	4-5	Grått	Bra fjell		
65,90	66,20	0,30	600	2000-2300	4-10	4-5				
66,20	66,70	0,50	600	2400-2800	3-6	4-5	Grått	Bra fjell		
66,70	67,10	0,40	600	2600-2800	0-5	4-5				
67,10	68,90	1,80	600	1800-2200	14-17	4-5	Grått	Bergartsgrense, 67,50 meter, mykere		
68,90	69,60	0,70	600	1800	15	4-30		Dårlig sone, fastboring		
69,60	71,90	2,30	600	1900-2300	3-11	4-5	Grått			
71,90	74,60	2,70	600	1800-2600	3-9	4-5		OK fjell		
74,60	77,70	3,10	600	1800-2100	15	4-5	Grått			
77,70	80,90	3,20	600	1700-1900	15	4-5		OK fjell		
80,90	83,90	3,00	600	2200-2400	15	5	Grått			
83,90	84,80	0,90	600	2400-2800	12-15	5		OK fjell		
84,80	86,90	2,10	600	1400-2700	15	5-9	Grått	Varierende hardhet, oppsprukket		
86,90	89,10	2,20	600	2600-2900	6-15	5				
89,10	89,50	0,40	600	2800-3200	0-11	3-4	Grått	Hardt fjell		
SUM	89,50	44,60								

GEO DRILLING AS		REGISTRERING BOREDATA					SIDE 3			
PROSJEKT: P - 170518		STED: Åknes			HULL-NR: BH - 01 - 18		KRONE: HQ	DATO: August	MASKIN: Diamec U-6 APC	FALL/RETNING: Lodd
FRA BOREDYP	TIL BOREDYP	KJERNE LENGDE	ROTASJON RPM	MATEKRAFT KILO	PENETRERING ca CM/MIN	Mottrykk Spyl.vann Bar	FARVE SPYLEVANN	KOMMENTAR		
89,50	92,60	3,10	600	2300-2800	15	4-5	Grått	Fint fjell, noen kiler		
92,60	95,70	3,10	600	2500-2900	12-15	5-6				
95,70	97,70	2,00	600	2700-3000	5-15	4-5	Grått	Hardt fjell		
97,70	98,00	0,30	600	3000	3	4-5				
98,00	98,10	0,10	550	3000-3200	0-3	4	Grått	Hardt fjell		
98,10	98,90	0,80	550	2300-2700	15	4-5				
98,90	101,70	2,80	600	2200-2700	15	5-6	Grått	Mykere, fint		
101,70	103,30	1,60	600	2300-2700	11-15	4-11				
103,30	104,90	1,60	600	2300-2700	8-13	4-8	Grått	Sprukkede soner		
104,90	105,40	0,50	600	1200-1800	10-15	4-16				
105,40	107,90	2,50	600	1800-2600	8-14	4-6	Grått	Fint fjell, noen kiler		
107,90	110,90	3,00	600	2300-2700	8-12	4-12				
110,90	111,30	0,40	600	2400-2500	9-13	5-20	Grått	Qartssoner, kilende		
111,30	111,60	0,30	600	2700-2900	3-7	5-11				
111,60	112,00	0,40	600	2800-3100	2-6	3-4	Grått	Hardt fint fjell		
112,00	113,90	1,90	600	2300-3000	9-13	6-7				
113,90	116,50	2,60	600	2800-3000	8-13	6-15	Grått	Fint fjell, noen kiler		
116,50	119,60	3,10	600	2700-3000	8-12	6-20				
119,60	120,00	0,40	600	2400-2700	5-10	6-30	Grått	Fint fjell, noen kiler		
120,00	122,90	2,90	600	2200-2700	13-15	5-6				
122,90	125,90	3,00	600	2400-2800	12-15	5-6	Grått	Fint fjell, noen kiler		
125,90	128,90	3,00	600	2400-2800	11-15	5-6				
128,90	131,90	3,00	600	1900-2600	12-15	5-6	Grått	Fint fjell, noen kiler		
131,90	134,90	3,00	600	1800-2400	13-15	5-6				
134,90	137,90	3,00	600	1700-2700	11-15	5-6	Grått	Fint fjell, noen kiler		
137,90	140,90	3,00	600	1700-2200	12-15	5-7				
140,90	143,90	3,00	600	1800-2200	13-15	0-7	Grått	Fint fjell, noen kiler		
143,90	146,90	3,00	600	1500-2200	15	3-4				
146,90	149,90	3,00	600	1800-2800	10-15	0-3	Grått	Fint fjell, noen kiler		
149,90	152,90	3,00	600	2000-2900	8-15	0-3				
152,90	154,40	1,50	600	2800-3100	3-7	0-3	Grått	Fint fjell, noen kiler		
SUM	154,40	64,90								

GEO DRILLING AS		REGISTRERING BOREDATA						SIDE 4		GEO DRILLING
PROSJEKT: P - 170518		STED: Åknes			HULL-NR: BH - 01 - 18		KRONE: HQ	DATO: August	MASKIN: Diamec U-6 APC	FALL/RETNING: Lodd
FRA BOREDYP	TIL BOREDYP	KJERNE LENGDE	ROTASJON RPM	MATEKRAFT KILO	PENETRERING ca CM/MIN	Mottrykk Spyl.vann Bar	FARVE SPYLEVANN	KOMMENTAR		
154,40	155,90	1,50	600	2000	14-15	4	Grått	Fint fjell		
155,90	158,90	3,00	600	1500-2800	13-15	3				
158,90	160,50	1,60	600	2700-2900	3-10	3		Fint fjell		
160,50	160,70	0,20	600	2200-2500	5-12	3				
160,70	161,90	1,20	600	2700-3000	13-15	3		Fint fjell		
161,90	164,90	3,00	600	2300-3000	3-14	3				
164,90	167,90	3,00	600	2800-3200	6-12	3		Fint fjell		
167,90	170,80	2,90	600	3000-3200	6-10	3				
170,80	172,30	1,50	600	3000-3200	3-7	3		Fint fjell		
172,30	173,90	1,60	600	3000-3100	10-15	3				
173,90	176,80	2,90	600	3000-3200	3-13	3		Fint fjell		
176,80	177,00	0,20	600	3100-3300	0-4	3				
177,00	179,90	2,90	600	1600-1900	15	3		Fint fjell		
179,90	182,90	3,00	600	1500-1800	15	3				
182,90	185,90	3,00	600	1600-2100	15	3		Fint fjell		
185,90	188,90	3,00	600	1500-2100	15	3-4				
188,90	191,90	3,00	600	1800-2400	15	3		Fint fjell		
191,90	194,90	3,00	600	2600-3000	9-14	3				
194,90	197,90	3,00	600	2200-2400	15	3		Fint fjell		
197,90	200,90	3,00	600	1800-2400	15	3				
200,90	203,90	3,00	600	2700-3100	5-15	3		Fint fjell		
203,90	206,90	3,00	600	1800-3200	15	3-4				
206,90	209,90	3,00	600	2000-3100	11-15	3		Fint fjell		
209,90	212,90	3,00	600	1800-2400	15	3				
212,90	215,90	3,00	600	1800-2300	15	3		Fint fjell		
215,90	218,90	3,00	600	1800-2300	15	3				
218,90	219,50	0,60	600	1800-2200	15	3-20		Fint fjell, mye slam		
219,50	221,90	2,40	600	1600-2200	15	3-11		Mykere bergart, noe delt		
221,90	222,60	0,70	600	1800-2100	15	4-20		Fint fjell		
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Appendix B

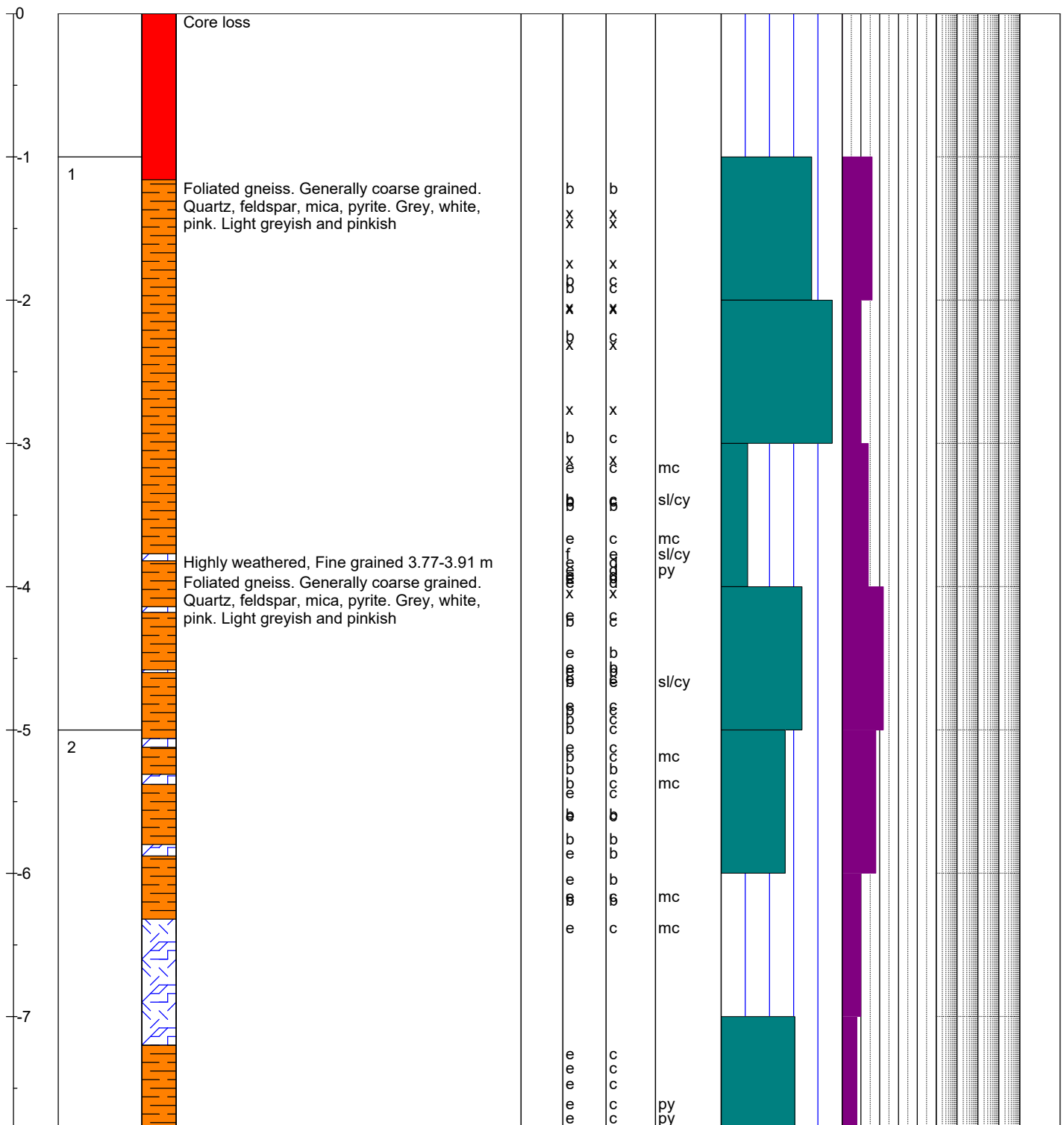
CORE LOGGING SHEETS (LOGPLOT) KH-01-2018





Contents

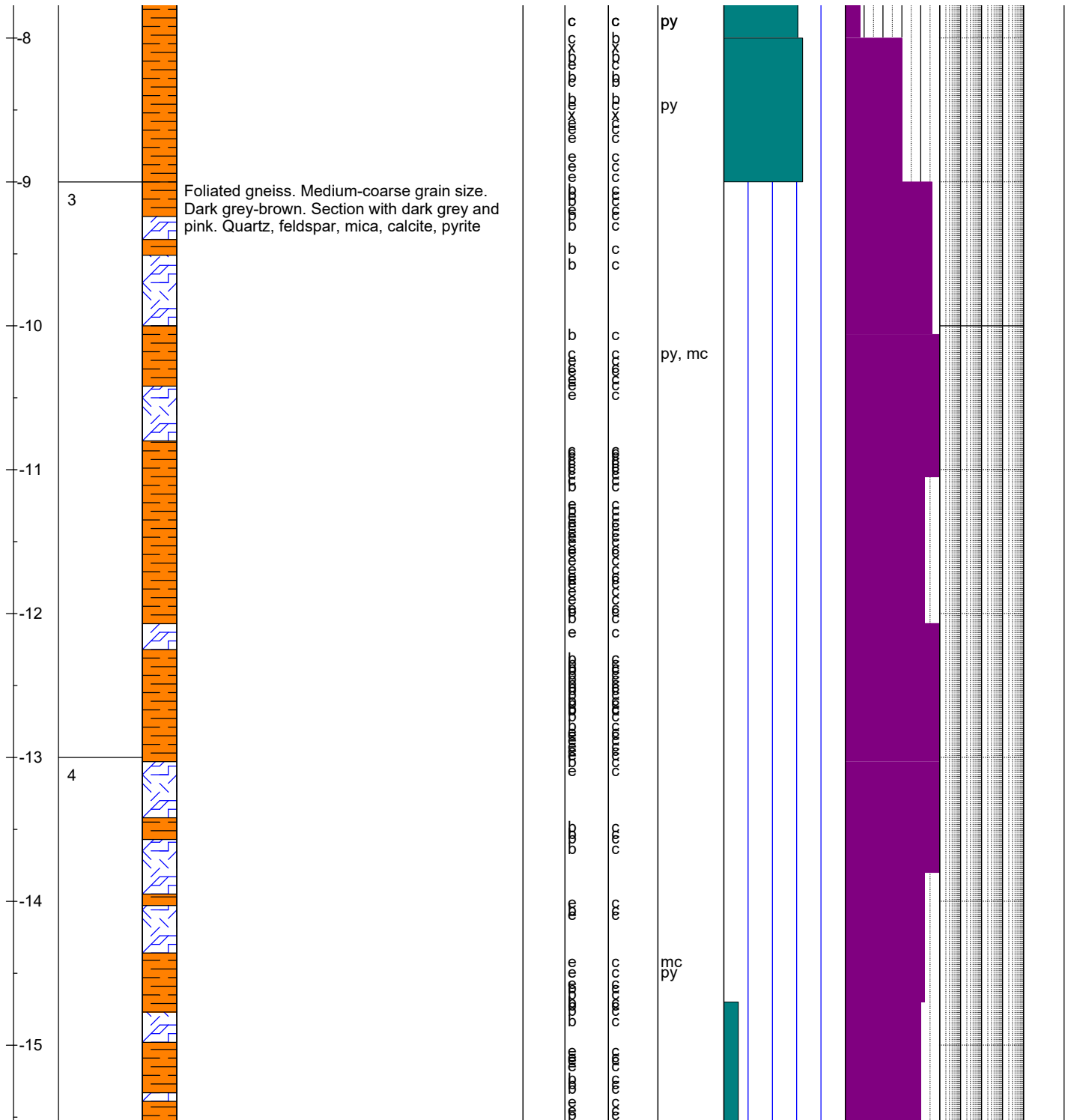
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B1 Core logging sheets (Logplot) KH-01-2018

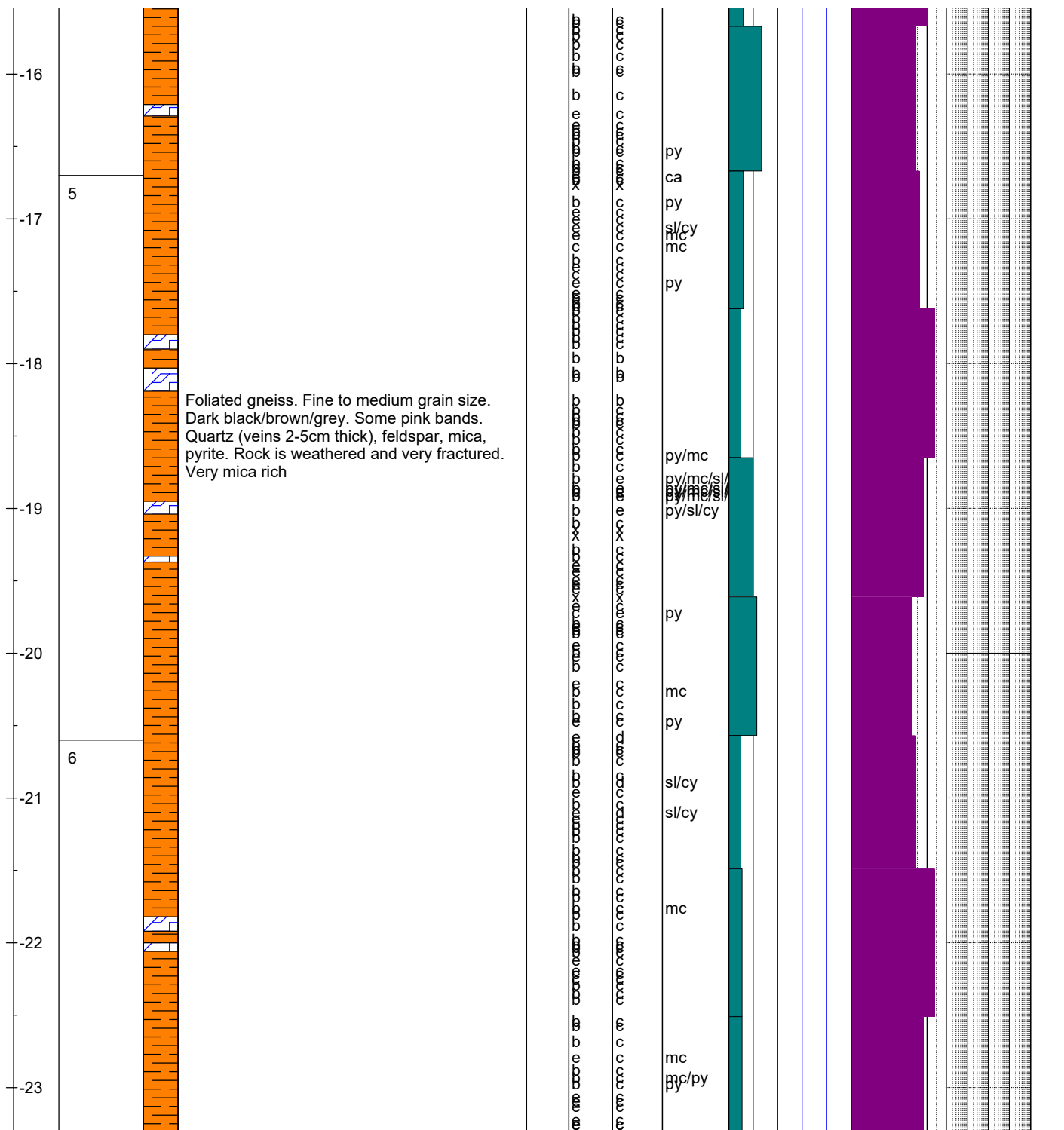
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REPORT NO.: 20180662 PROJECT NAME: Åknes drainage		ROCK TYPE:  Gneiss		ZONES:  Fractured zone  Core loss		JOINT INFILL MATERIAL: cy, Clay ca, calcite mc, Mica py, Pyrite sl, Silt qz, Quartz					
DRILLED LENGTH: 222,6 ELEVATION: 592,9 ORIENTATION: Vertical LOGGING DATE: 2018-10 to 2018-11 NAME: Lise Tønset and Henrik Langeland File: P:\2018\06\20180662\Beregninger\Borehull\KH-01-2018\Logplot											
HOLE DEPTH	BOX NO.	ROCK TYPE	DESCRIPTION/COMMENTS	CORELOSS, CM	Jr	Ja	Joint infill material	RQD, %	JOINT FREQUENCY natural joints pr. m.	WATERLOSS MEASUREMENT Lugeon	OVERPRESSURE, MPa
								20 40 60 80	5 10 15 20	1 10 100	







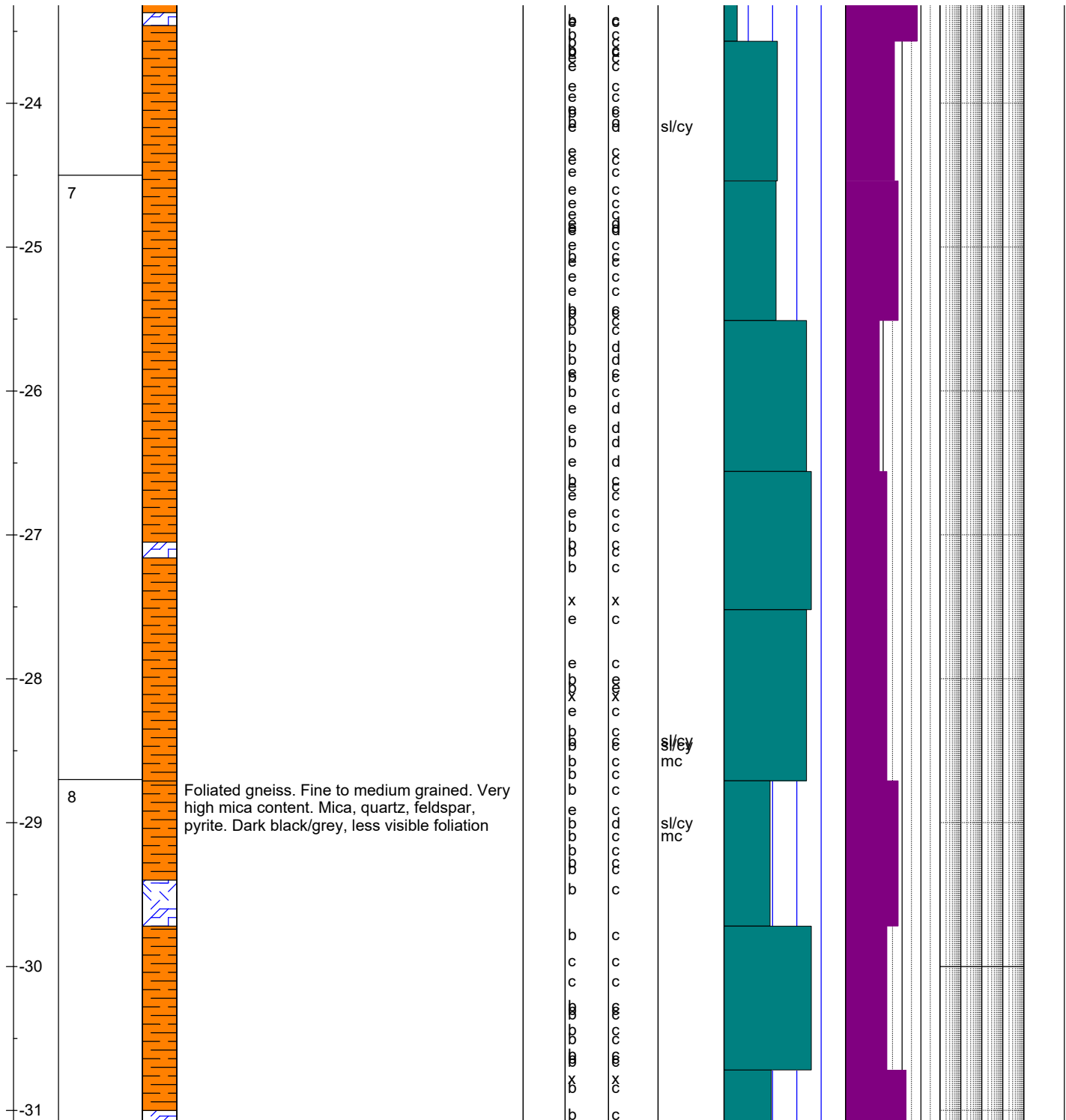
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REPORT NO.: 20180662 PROJECT NAME: Åknes drainage		ROCK TYPE:  Gneiss		ZONES:  Fractured zone  Core loss		JOINT INFILL MATERIAL: cy, Clay ca, calcite mc, Mica py, Pyrite sl, Silt qz, Quartz					
DRILLED LENGTH: 222,6 ELEVATION: 592,9 ORIENTATION: Vertical LOGGING DATE: 2018-10 to 2018-11 NAME: Lise Tønset and Henrik Langeland File: P:\2018\06\20180662\Beregninger\Borehull\KH-01-2018\Logplot											
HOLE DEPTH	BOX NO.	ROCK TYPE	DESCRIPTION/COMMENTS	CORELOSS, CM	Jr	Ja	Joint infill material	RQD, %	JOINT FREQUENCY natural joints pr. m.	WATERLOSS MEASUREMENT Lugeon	OVERPRESSURE, MPa
								20 40 60 80	5 10 15 20	1 10 100	







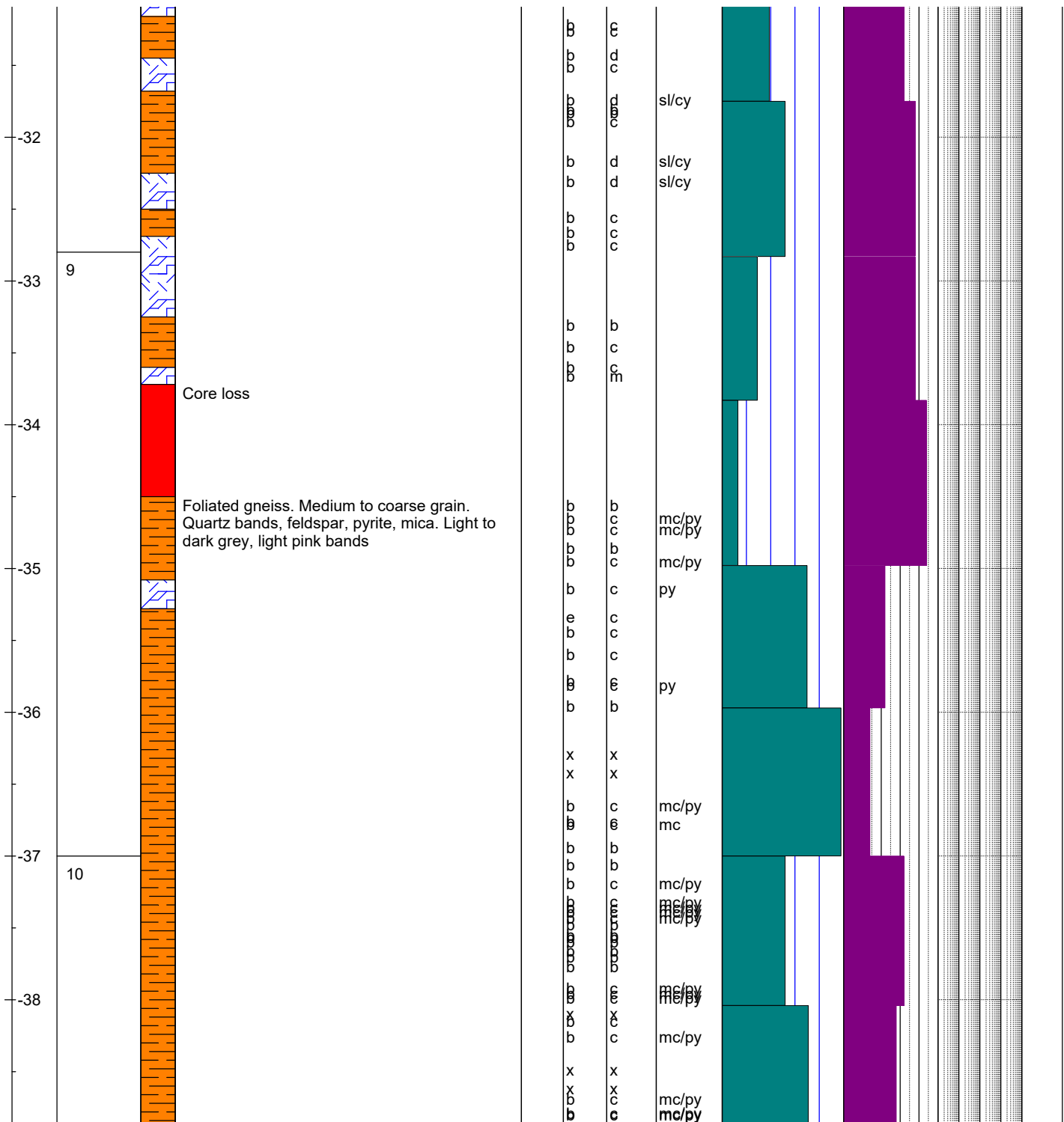
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DRILLED LENGTH: 222,6 ELEVATION: 592,9 ORIENTATION: Vertical LOGGING DATE: 2018-10 to 2018-11 NAME: Lise Tønset and Henrik Langeland File: P:\2018\06\20180662\Beregninger\Borehull\KH-01-2018\Logplot											
HOLE DEPTH	BOX NO.	ROCK TYPE	DESCRIPTION/COMMENTS	CORELOSS, CM	Jr	Ja	Joint infill material	RQD, %	JOINT FREQUENCY natural joints pr. m.	WATERLOSS MEASUREMENT Lugeon	OVERPRESSURE, MPa
								20 40 60 80	5 10 15 20	1 10 100	







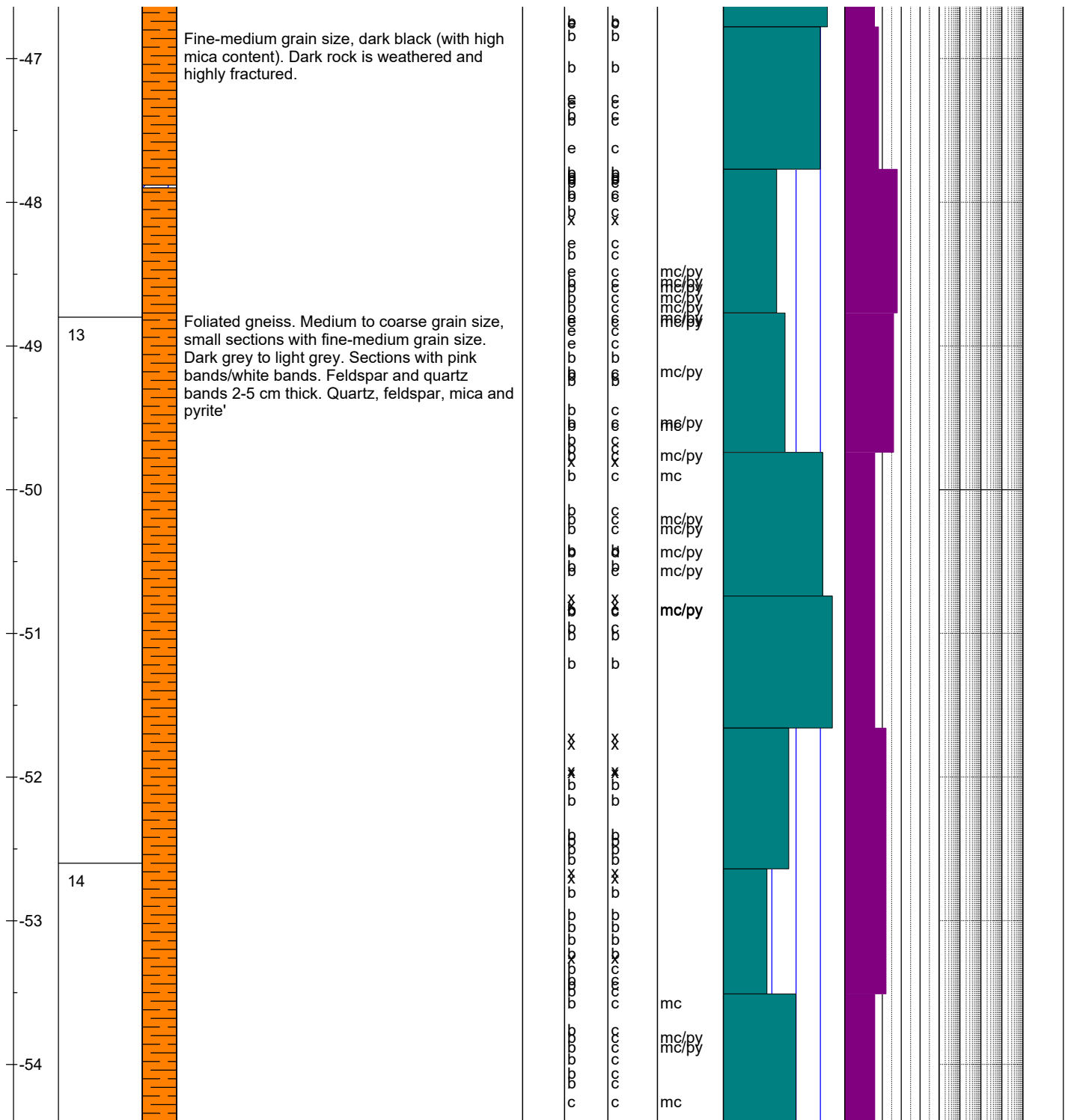
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DRILLED LENGTH: 222,6 ELEVATION: 592,9 ORIENTATION: Vertical LOGGING DATE: 2018-10 to 2018-11 NAME: Lise Tønset and Henrik Langeland File: P:\2018\06\20180662\Beregninger\Borehull\KH-01-2018\Logplot											
HOLE DEPTH	BOX NO.	ROCK TYPE	DESCRIPTION/COMMENTS	CORELOSS, CM	Jr	Ja	Joint infill material	RQD, %	JOINT FREQUENCY natural joints pr. m.	WATERLOSS MEASUREMENT Lugeon	OVERPRESSURE, MPa
								20 40 60 80	5 10 15 20	1 10 100	







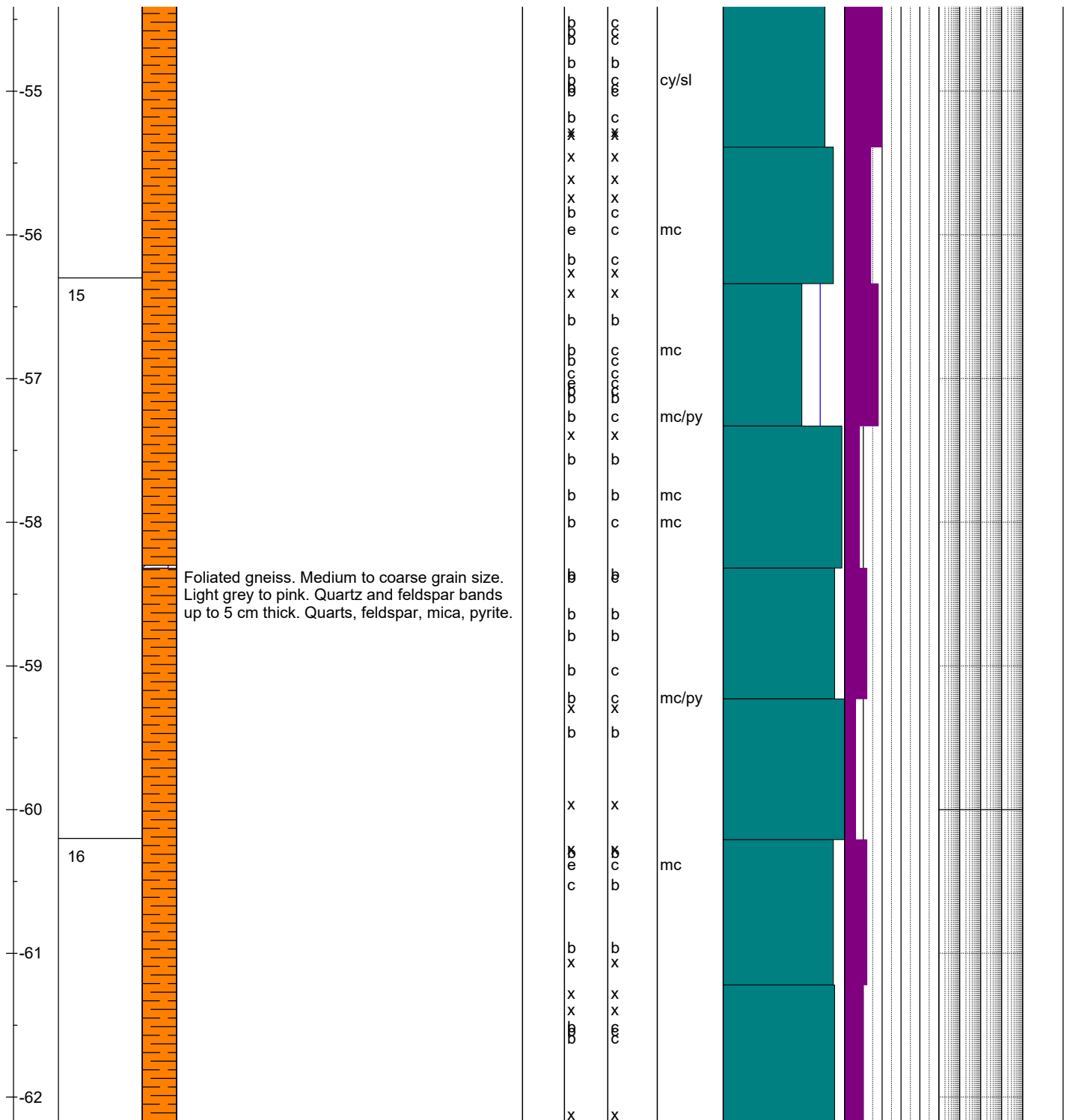
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DRILLED LENGTH: 222,6 ELEVATION: 592,9 ORIENTATION: Vertical LOGGING DATE: 2018-10 to 2018-11 NAME: Lise Tønset and Henrik Langeland File: P:\2018\06\20180662\Beregninger\Borehull\KH-01-2018\Logplot																
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								20	40	60	80		1	10	100	







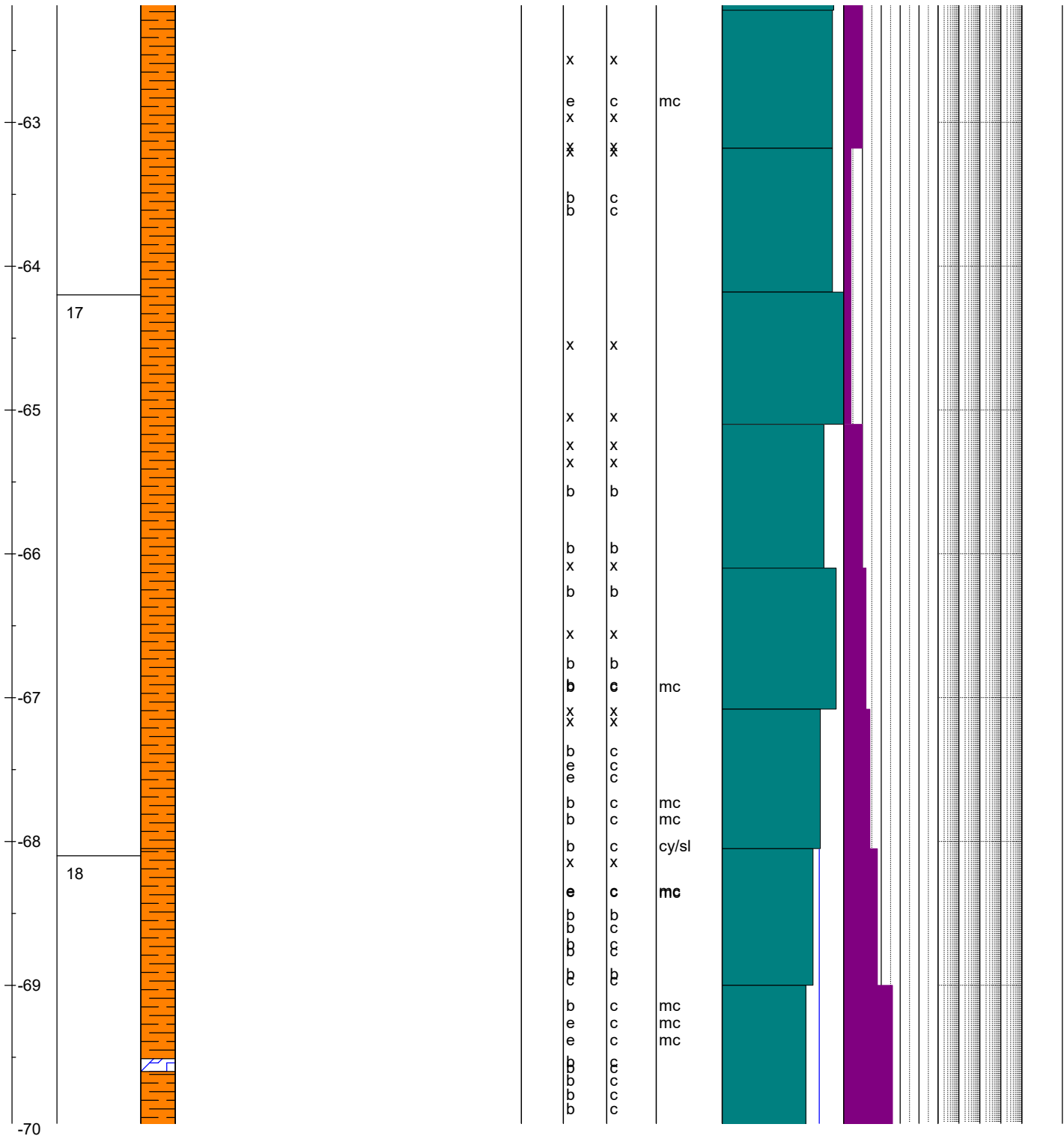
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DRILLED LENGTH: 222,6 ELEVATION: 592,9 ORIENTATION: Vertical LOGGING DATE: 2018-10 to 2018-11 NAME: Lise Tønset and Henrik Langeland File: P:\2018\06\20180662\Beregninger\Borehull\KH-01-2018\Logplot											
HOLE DEPTH	BOX NO.	ROCK TYPE	DESCRIPTION/COMMENTS	CORELOSS, CM	Jr	Ja	Joint infill material	RQD, %	JOINT FREQUENCY natural joints pr. m.	WATERLOSS MEASUREMENT Lugeon	OVERPRESSURE, MPa
								20 40 60 80	5 10 15 20	1 10 100	







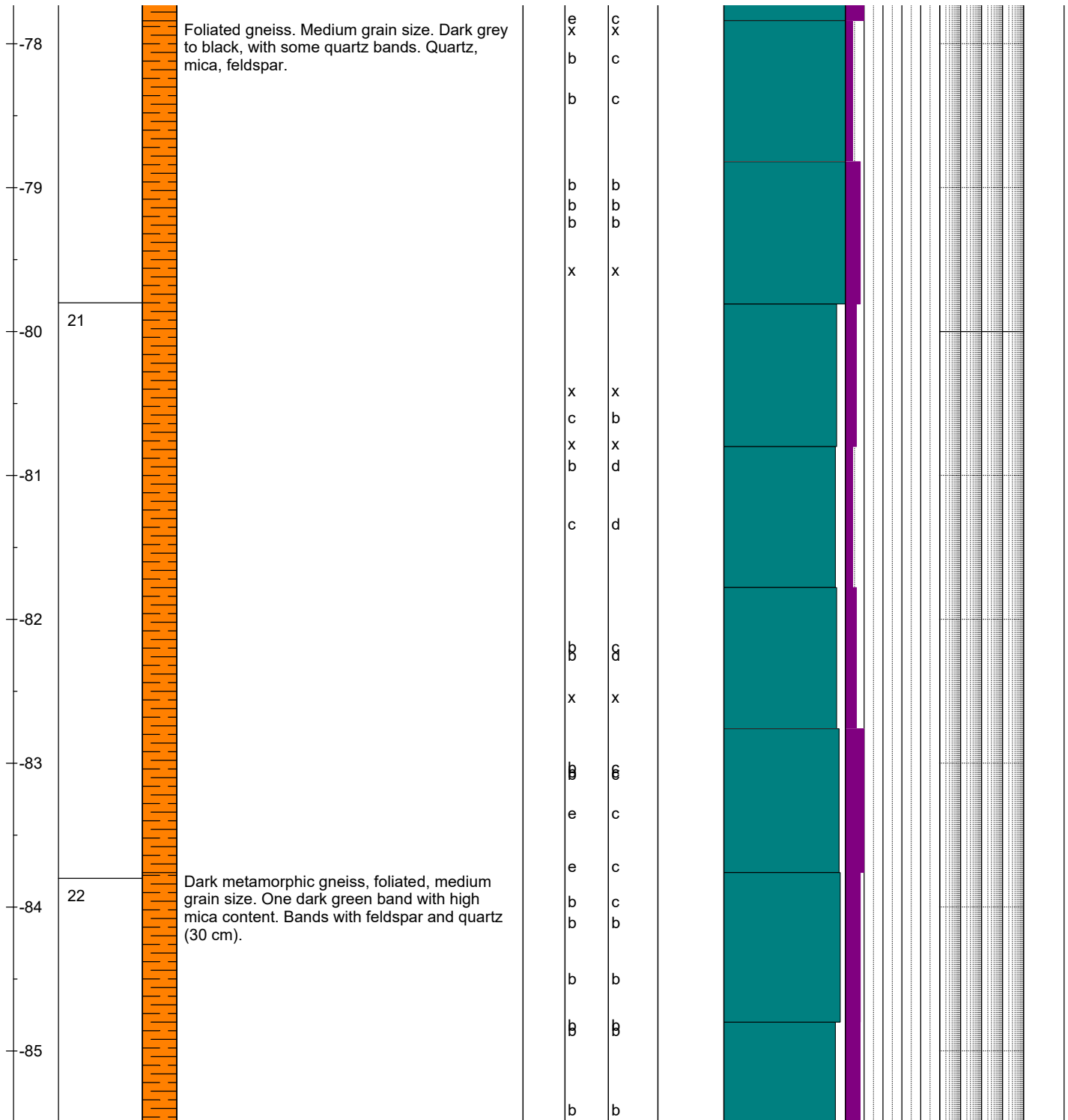
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REPORT NO.: 20180662 PROJECT NAME: Åknes drainage		ROCK TYPE:  Gneiss		ZONES:  Fractured zone  Core loss		JOINT INFILL MATERIAL: cy, Clay ca, calcite mc, Mica py, Pyrite sl, Silt qz, Quartz										
DRILLED LENGTH: 222,6 ELEVATION: 592,9 ORIENTATION: Vertical LOGGING DATE: 2018-10 to 2018-11 NAME: Lise Tønset and Henrik Langeland File: P:\2018\06\20180662\Beregninger\Borehull\KH-01-2018\Logplot																
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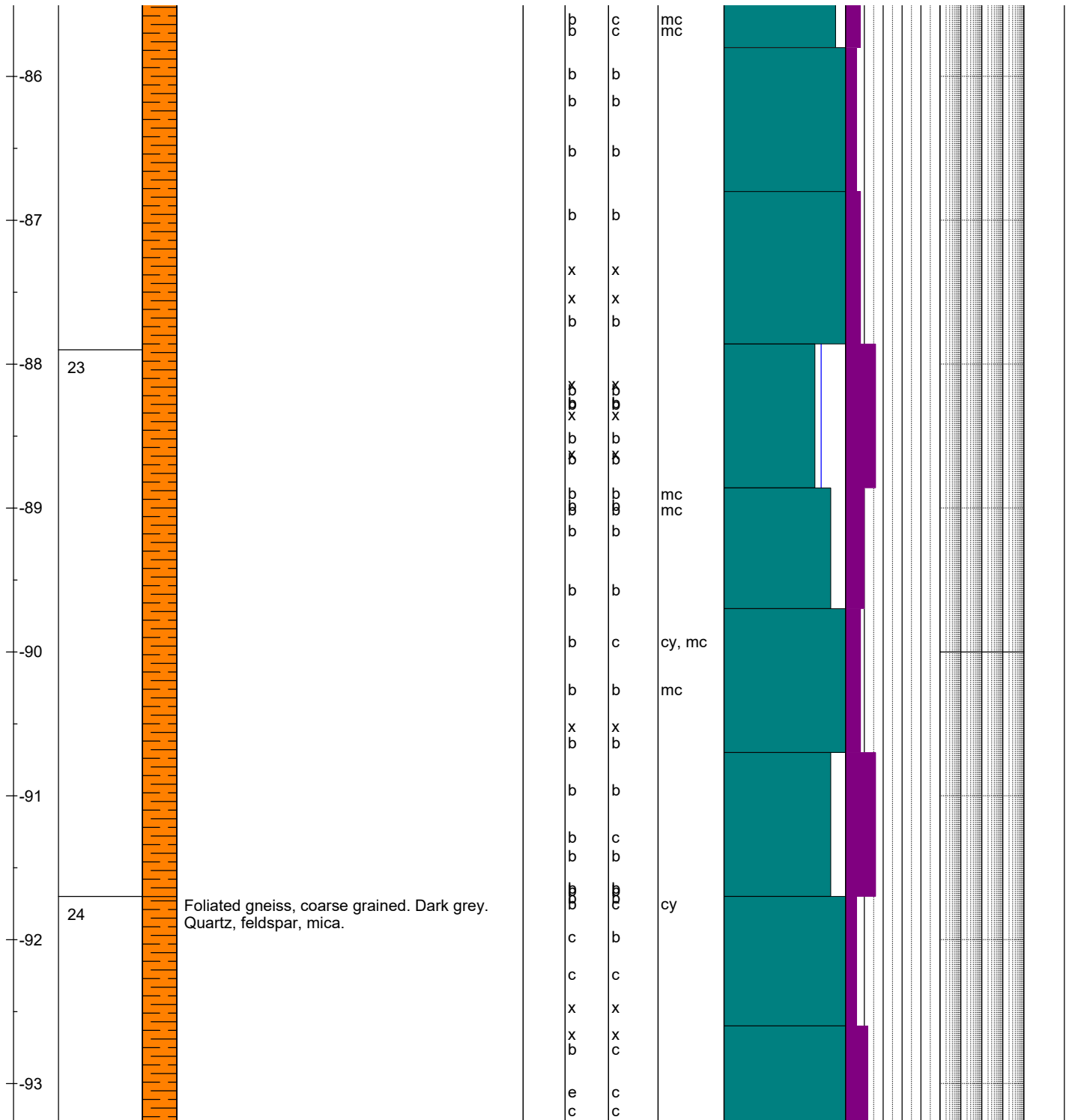
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REPORT NO.: 20180662 PROJECT NAME: Åknes drainage		ROCK TYPE:  Gneiss		ZONES:  Fractured zone  Core loss		JOINT INFILL MATERIAL: cy, Clay ca, calcite mc, Mica py, Pyrite sl, Silt qz, Quartz					
DRILLED LENGTH: 222,6 ELEVATION: 592,9 ORIENTATION: Vertical LOGGING DATE: 2018-10 to 2018-11 NAME: Lise Tønset and Henrik Langeland File: P:\2018\06\20180662\Beregninger\Borehull\KH-01-2018\Logplot											
HOLE DEPTH	BOX NO.	ROCK TYPE	DESCRIPTION/COMMENTS	CORELOSS, CM	Jr	Ja	Joint infill material	RQD, %	JOINT FREQUENCY natural joints pr. m.	WATERLOSS MEASUREMENT Lugeon	OVERPRESSURE, MPa
								20 40 60 80	5 10 15 20	1 10 100	







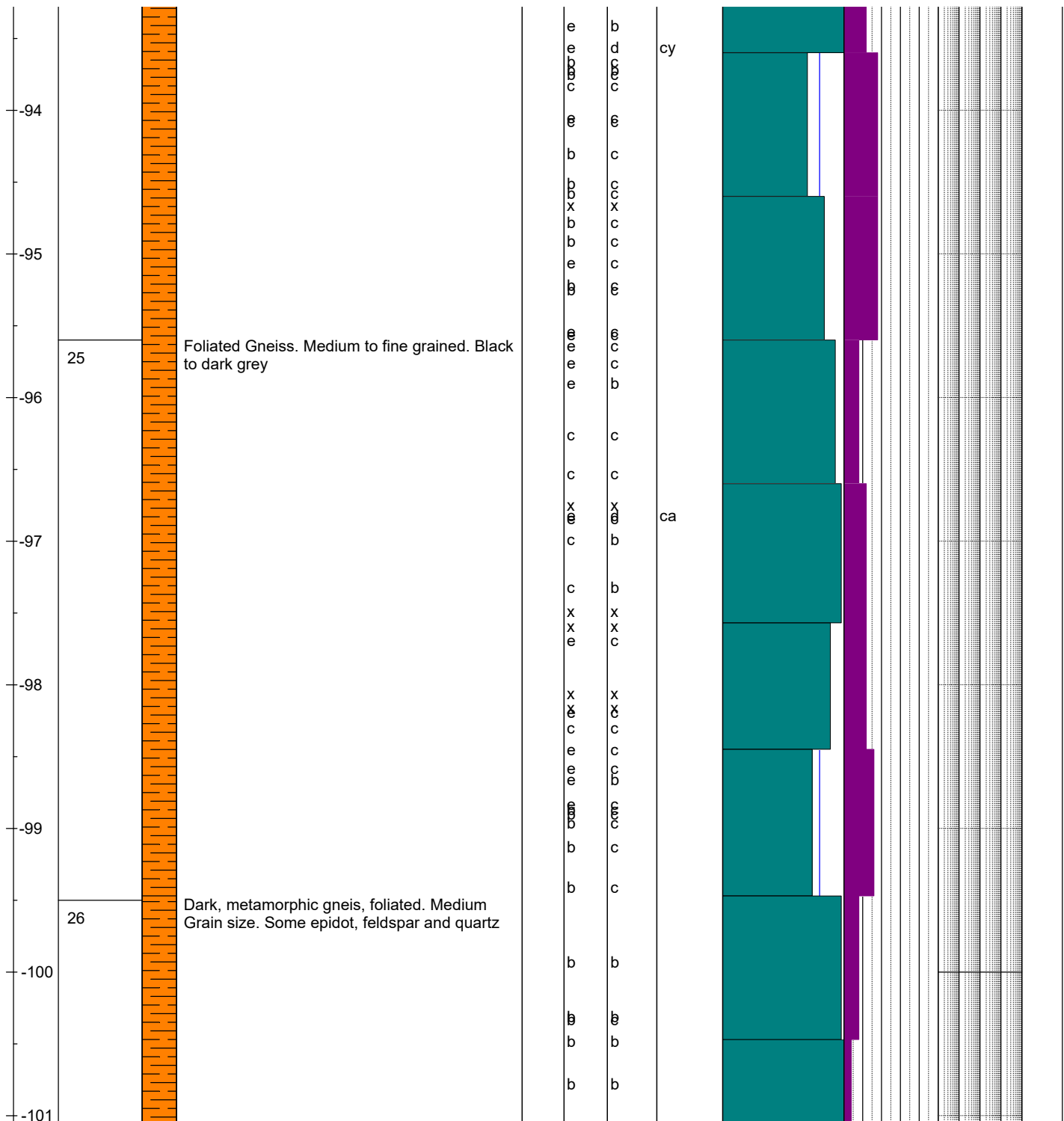
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REPORT NO.: 20180662 PROJECT NAME: Aknes drainage		ROCK TYPE:  Gneiss		ZONES:  Fractured zone  Core loss		JOINT INFILL MATERIAL: cy, Clay ca, calcite mc, Mica py, Pyrite sl, Silt qz, Quartz					
DRILLED LENGTH: 222,6 ELEVATION: 592,9 ORIENTATION: Vertical LOGGING DATE: 2018-10 to 2018-11 NAME: Lise Tønset and Henrik Langeland File: P:\2018\06\20180662\Beregninger\Borehull\KH-01-2018\Logplot											
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								20 40 60 80	5 10 15 20	1 10 100	







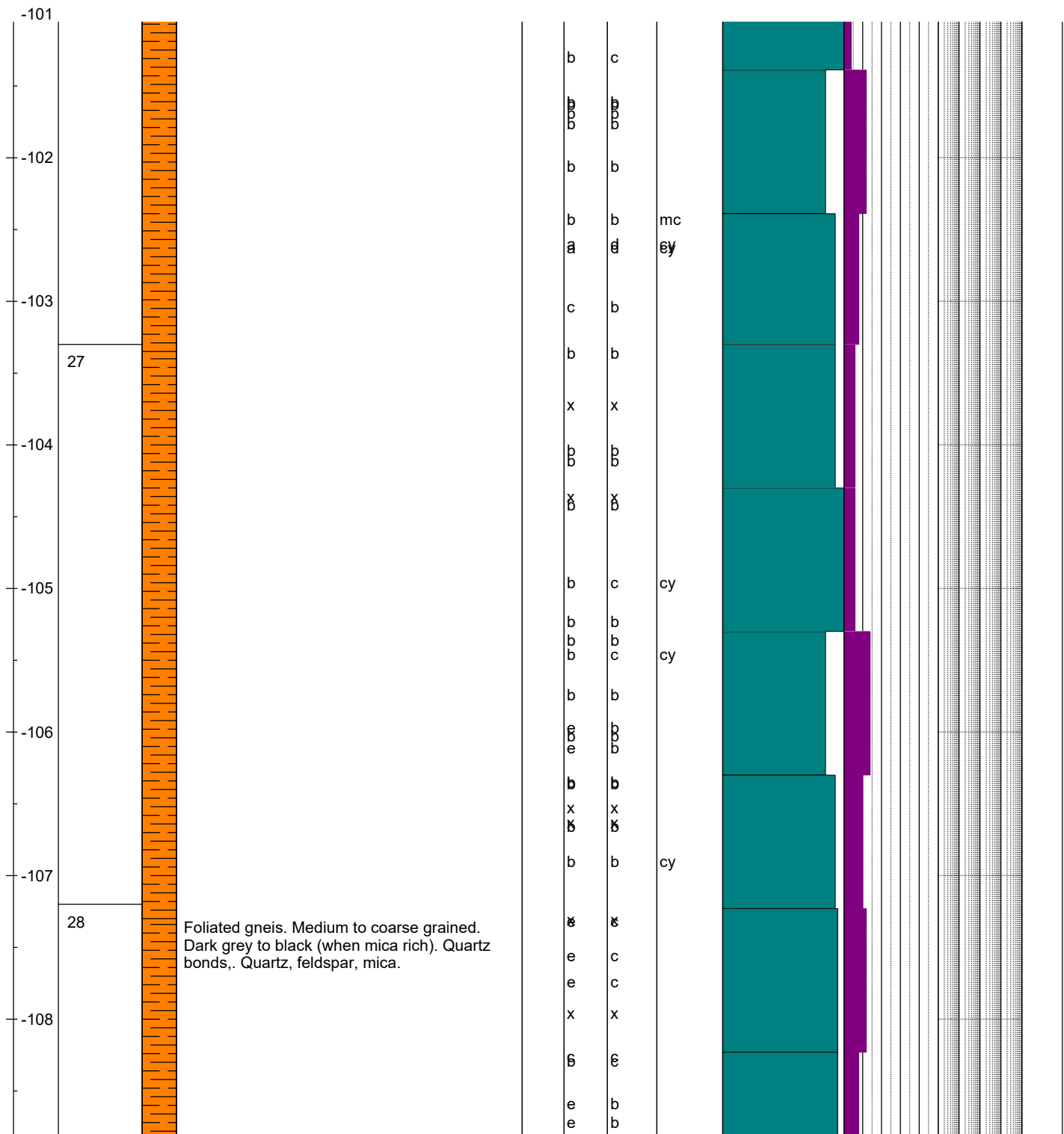
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DRILLED LENGTH: 222,6 ELEVATION: 592,9 ORIENTATION: Vertical LOGGING DATE: 2018-10 to 2018-11 NAME: Lise Tønset and Henrik Langeland File: P:\2018\06\20180662\Beregninger\Borehull\KH-01-2018\Logplot											
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								20 40 60 80	5 10 15 20	1 10 100	







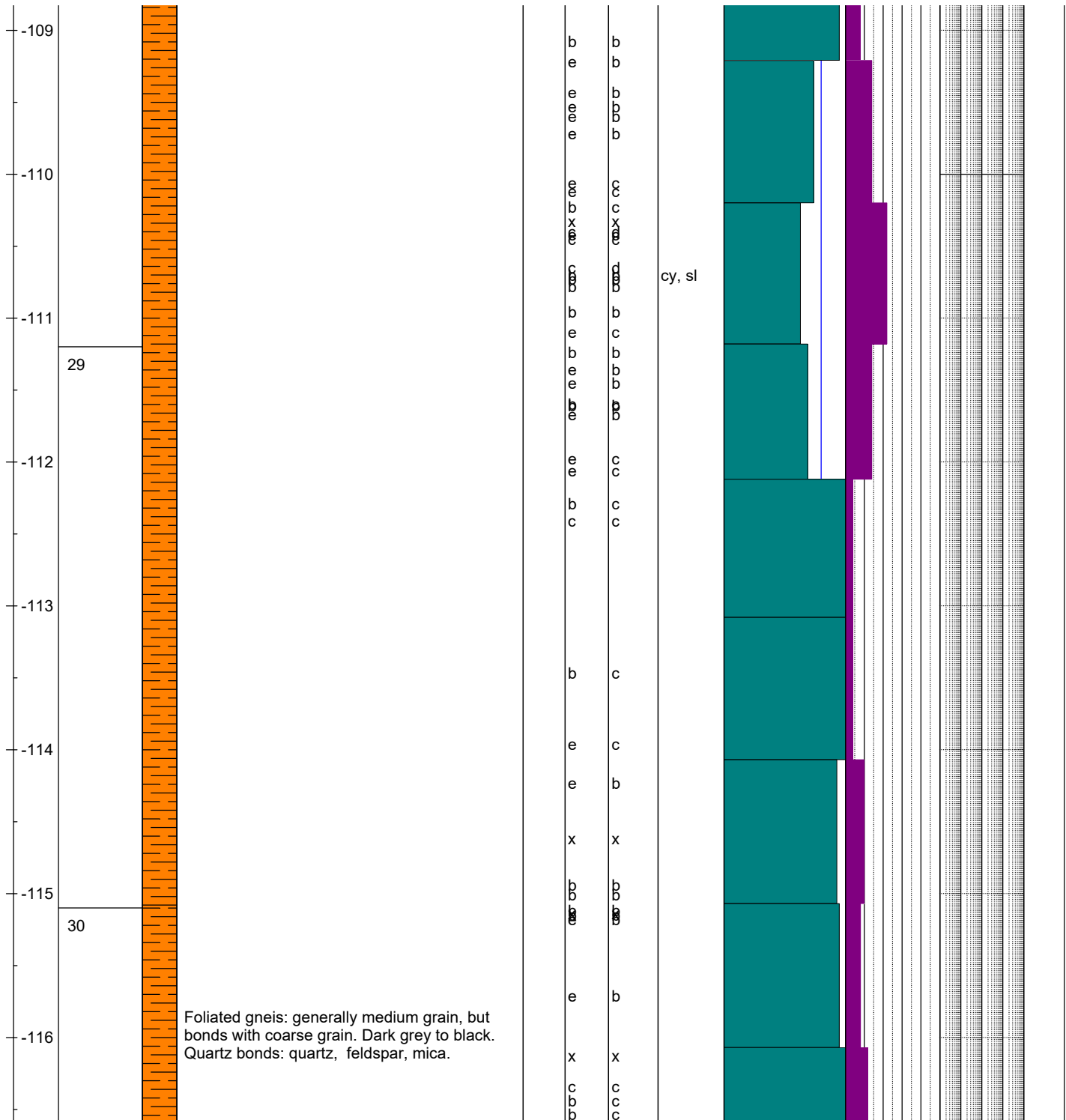
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REPORT NO.: 20180662 PROJECT NAME: Aknes drainage		ROCK TYPE:  Gneiss		ZONES:  Fractured zone  Core loss		JOINT INFILL MATERIAL: cy, Clay ca, calcite mc, Mica py, Pyrite sl, Silt qz, Quartz					
DRILLED LENGTH: 222,6 ELEVATION: 592,9 ORIENTATION: Vertical LOGGING DATE: 2018-10 to 2018-11 NAME: Lise Tønset and Henrik Langeland File: P:\2018\06\20180662\Beregninger\Borehull\KH-01-2018\Logplot											
HOLE DEPTH	BOX NO.	ROCK TYPE	DESCRIPTION/COMMENTS	CORELOSS, CM	Jr	Ja	Joint infill material	RQD, %	JOINT FREQUENCY natural joints pr. m.	WATERLOSS MEASUREMENT Lugeon	OVERPRESSURE, MPa
								20 40 60 80	5 10 15 20	1 10 100	







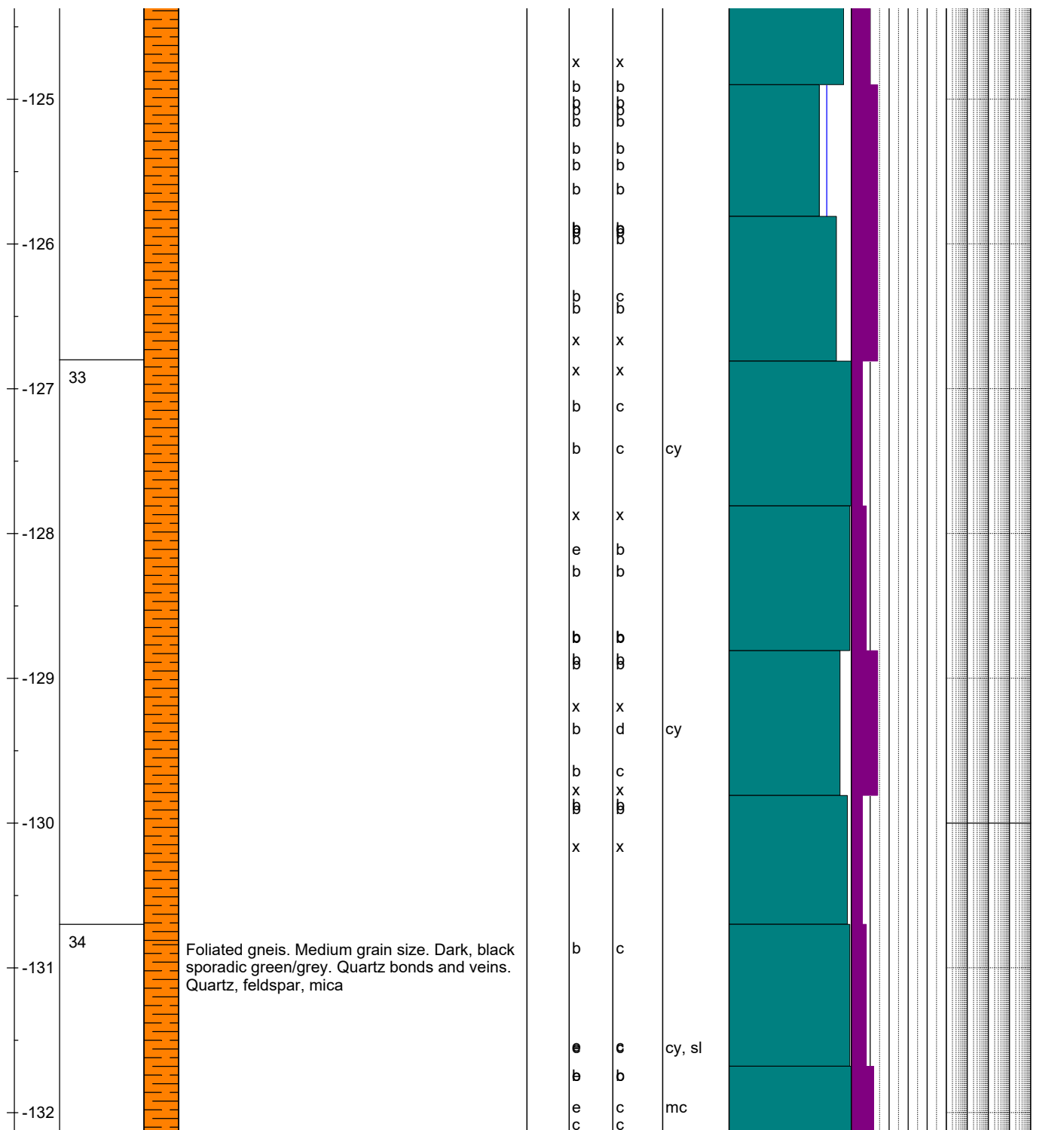
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DRILLED LENGTH: 222,6 ELEVATION: 592,9 ORIENTATION: Vertical LOGGING DATE: 2018-10 to 2018-11 NAME: Lise Tønset and Henrik Langeland File: P:\2018\06\20180662\Beregninger\Borehull\KH-01-2018\Logplot																
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								20	40	60	80		1	10	100	







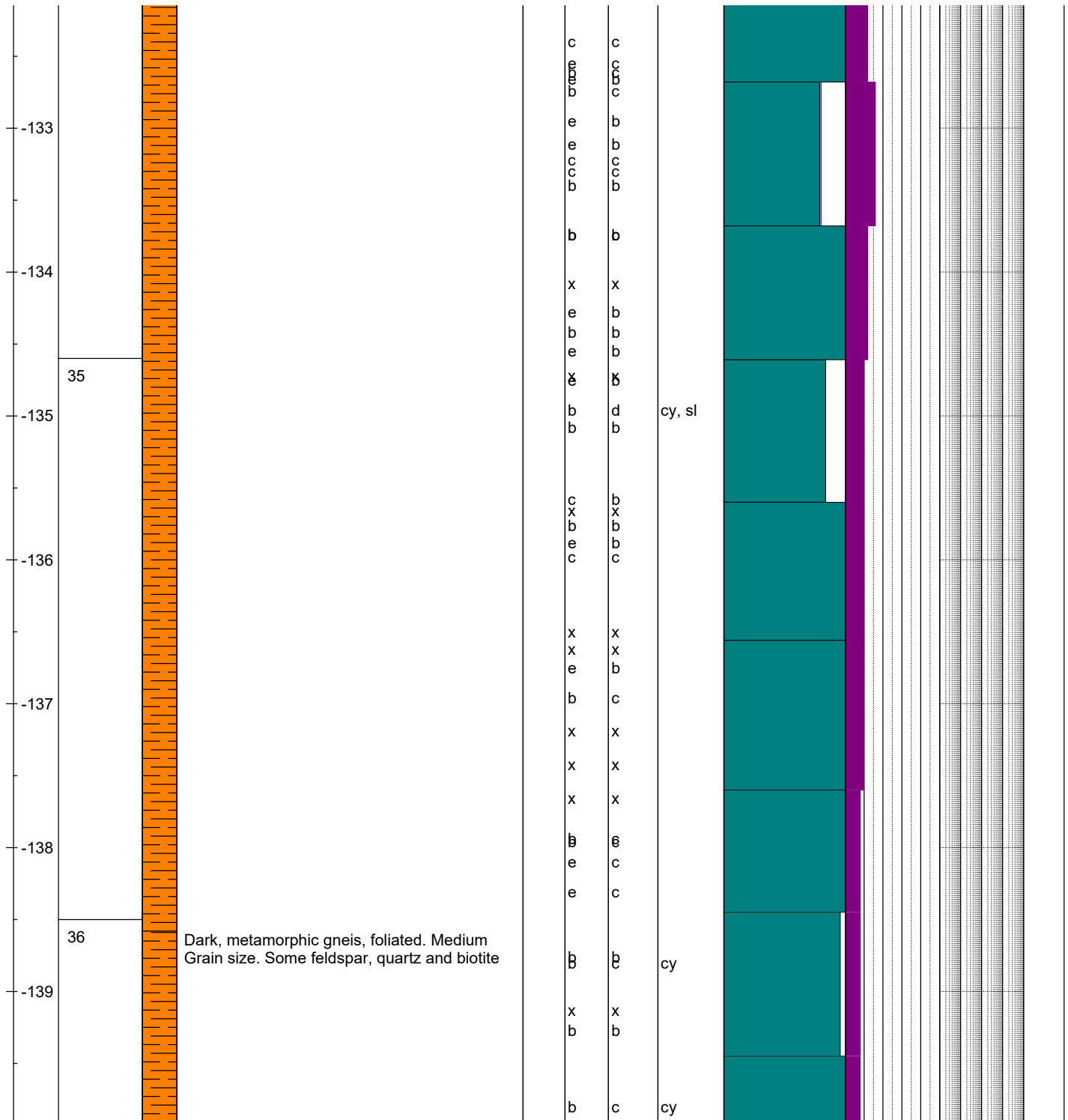
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REPORT NO.: 20180662 PROJECT NAME: Åknes drainage		ROCK TYPE:  Gneiss		ZONES:  Fractured zone  Core loss		JOINT INFILL MATERIAL: cy, Clay ca, calcite mc, Mica py, Pyrite sl, Silt qz, Quartz					
DRILLED LENGTH: 222,6 ELEVATION: 592,9 ORIENTATION: Vertical LOGGING DATE: 2018-10 to 2018-11 NAME: Lise Tønset and Henrik Langeland File: P:\2018\06\20180662\Beregninger\Borehull\KH-01-2018\Logplot											
HOLE DEPTH	BOX NO.	ROCK TYPE	DESCRIPTION/COMMENTS	CORELOSS, CM	Jr	Ja	Joint infill material	RQD, %	JOINT FREQUENCY natural joints pr. m.	WATERLOSS MEASUREMENT Lugeon	OVERPRESSURE, MPa
								20 40 60 80	5 10 15 20	1 10 100	







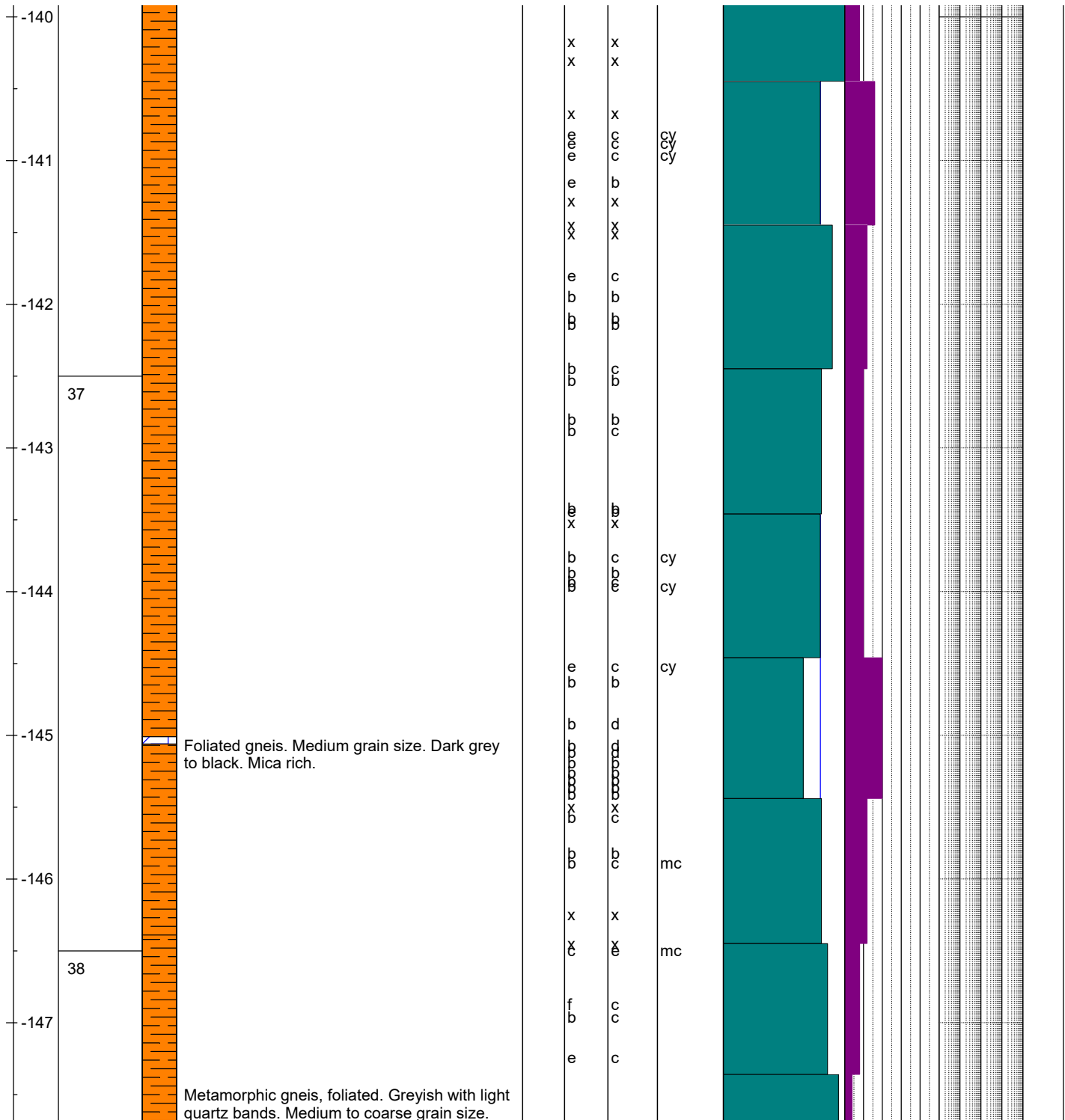
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REPORT NO.: 20180662 PROJECT NAME: Åknes drainage		ROCK TYPE:  Gneiss		ZONES:  Fractured zone  Core loss		JOINT INFILL MATERIAL: cy, Clay ca, calcite mc, Mica py, Pyrite sl, Silt qz, Quartz					
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								20 40 60 80	5 10 15 20	1 10 100	







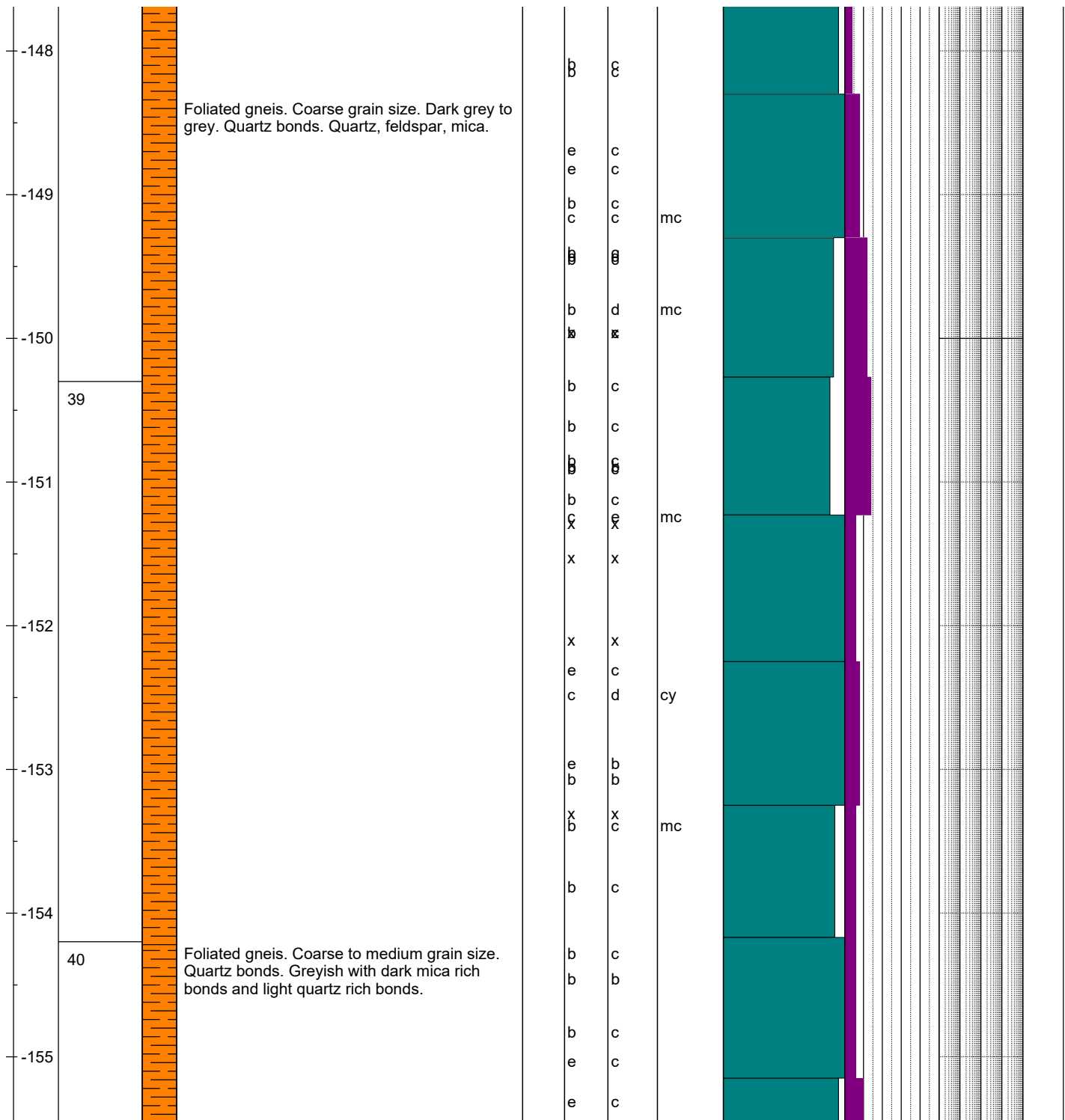
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								20 40 60 80	5 10 15 20	1 10 100	







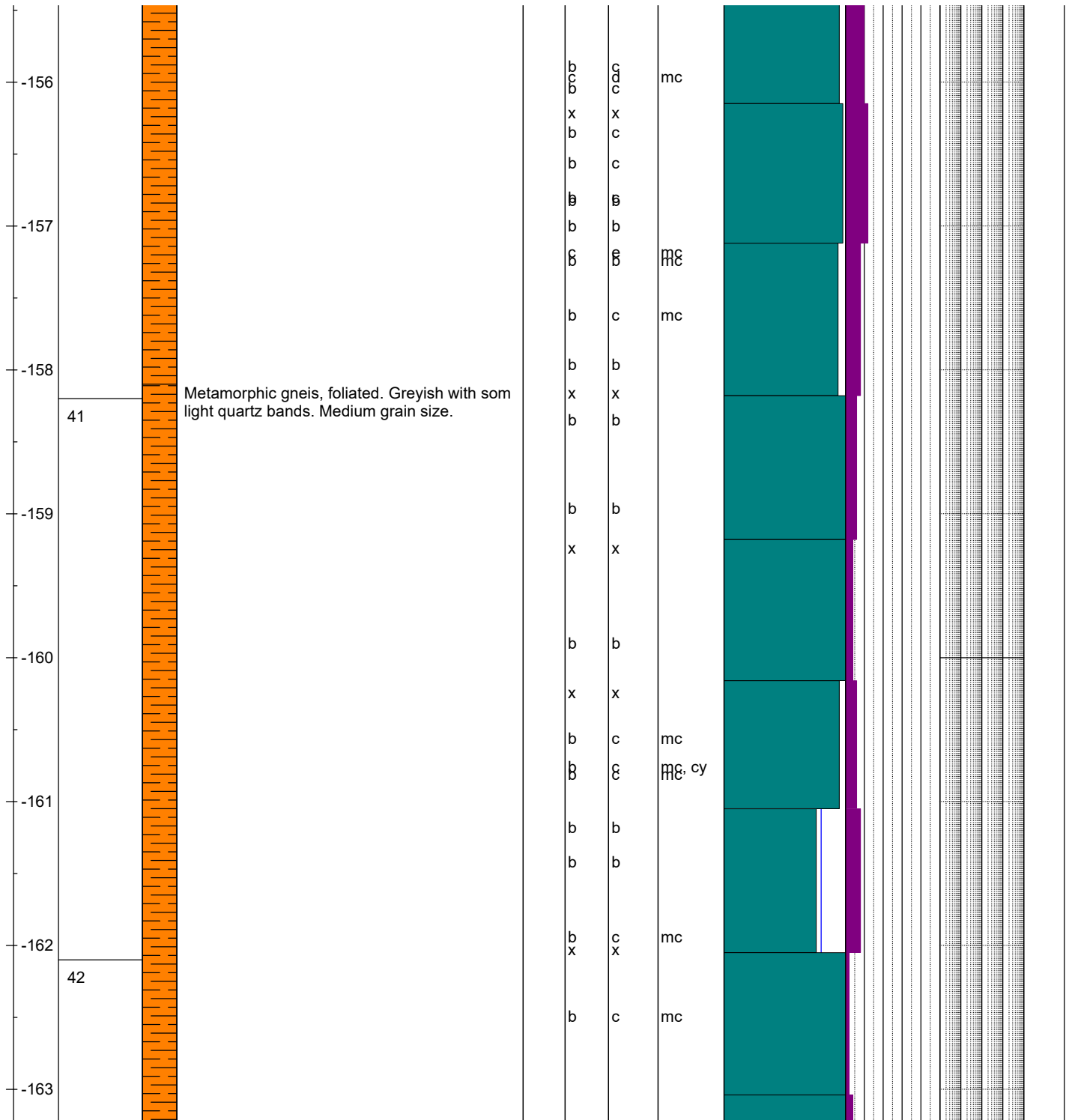
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REPORT NO.: 20180662 PROJECT NAME: Åknes drainage		ROCK TYPE:  Gneiss		ZONES:  Fractured zone  Core loss		JOINT INFILL MATERIAL: cy, Clay ca, calcite mc, Mica py, Pyrite sl, Silt qz, Quartz										
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								20	40	60	80		1	10	100	







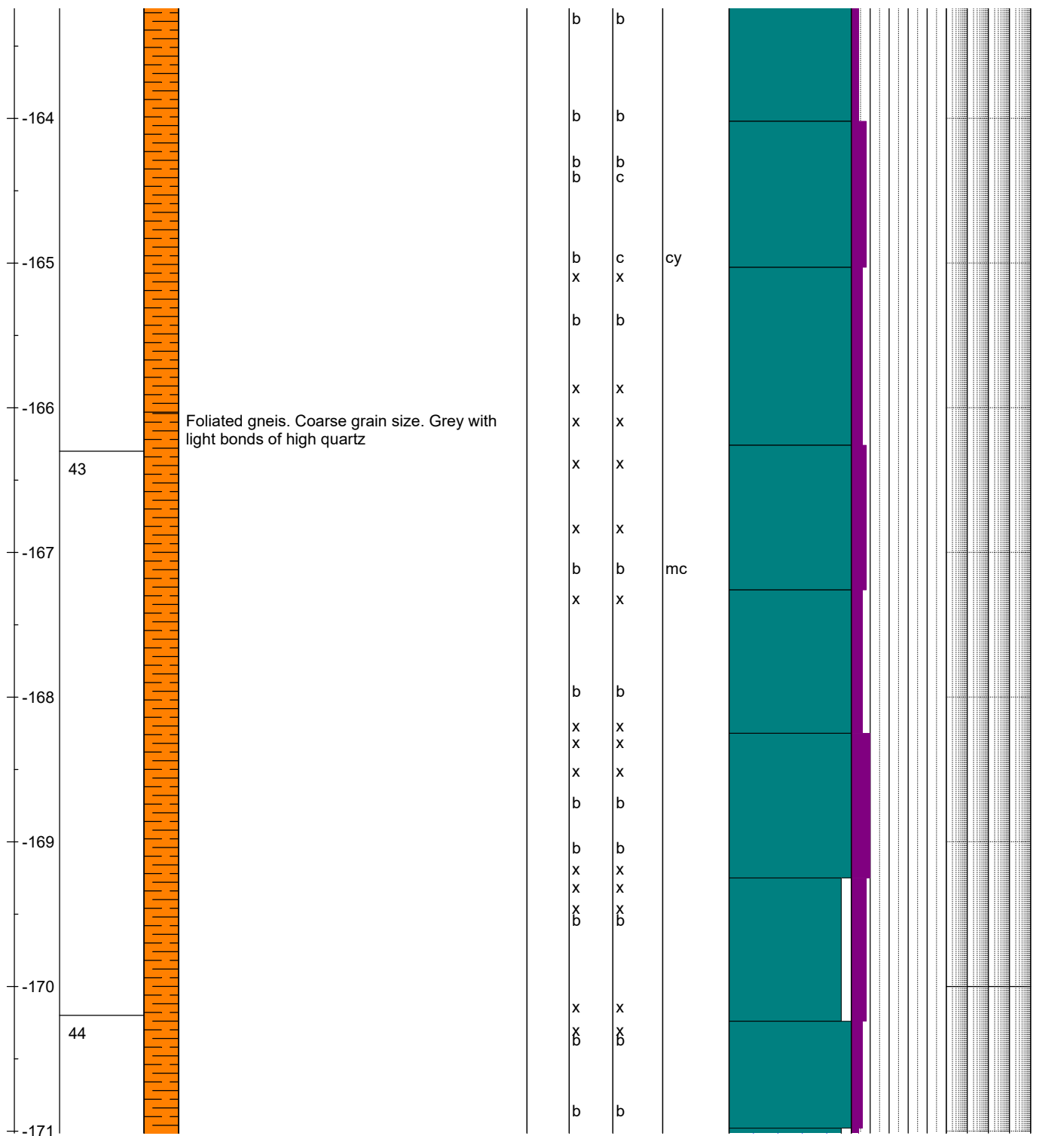
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								20	40	60	80		1	10	100	







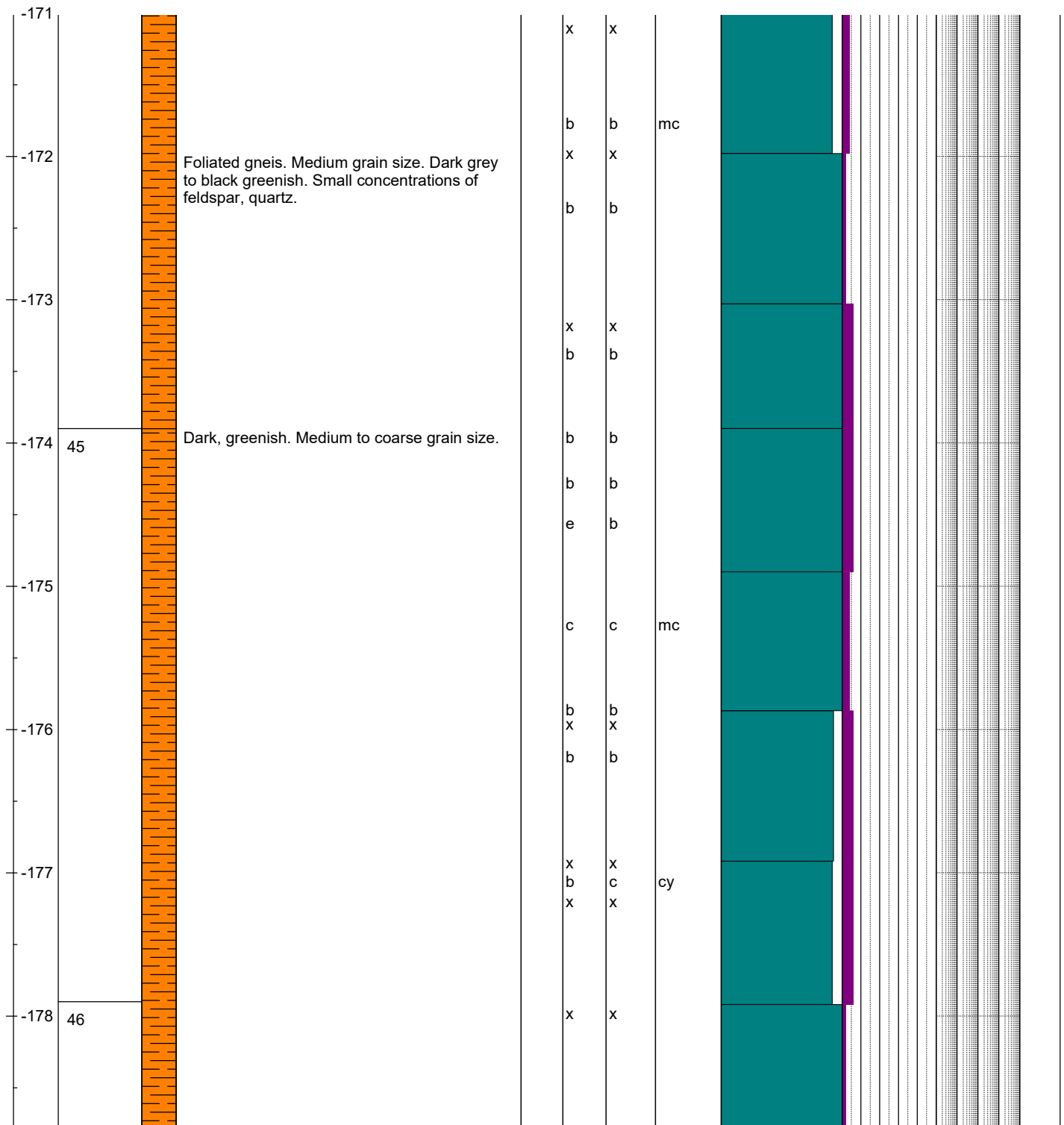
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								20	40	60	80		1	10	100	







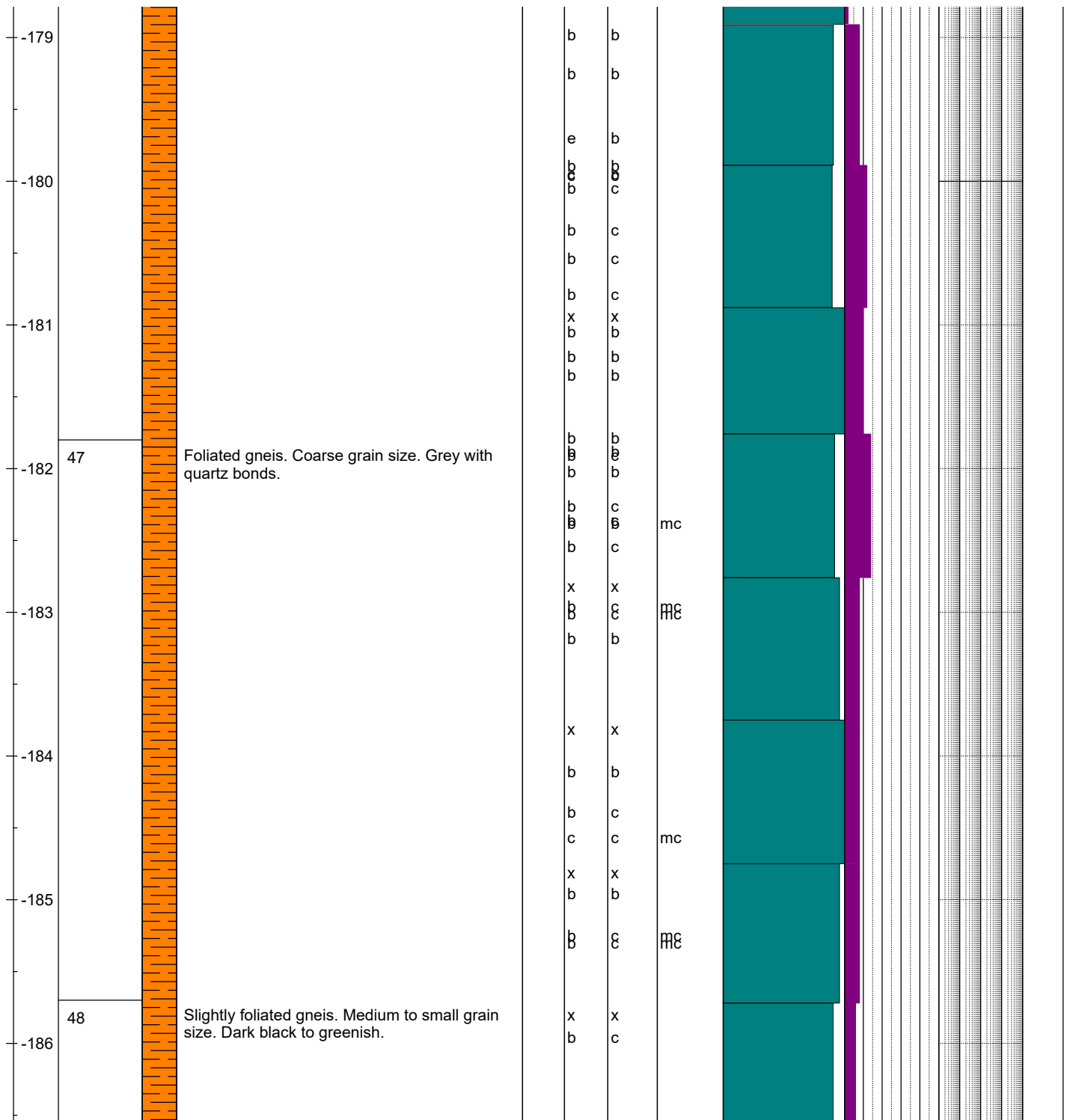
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								20	40	60	80		1	10	100	







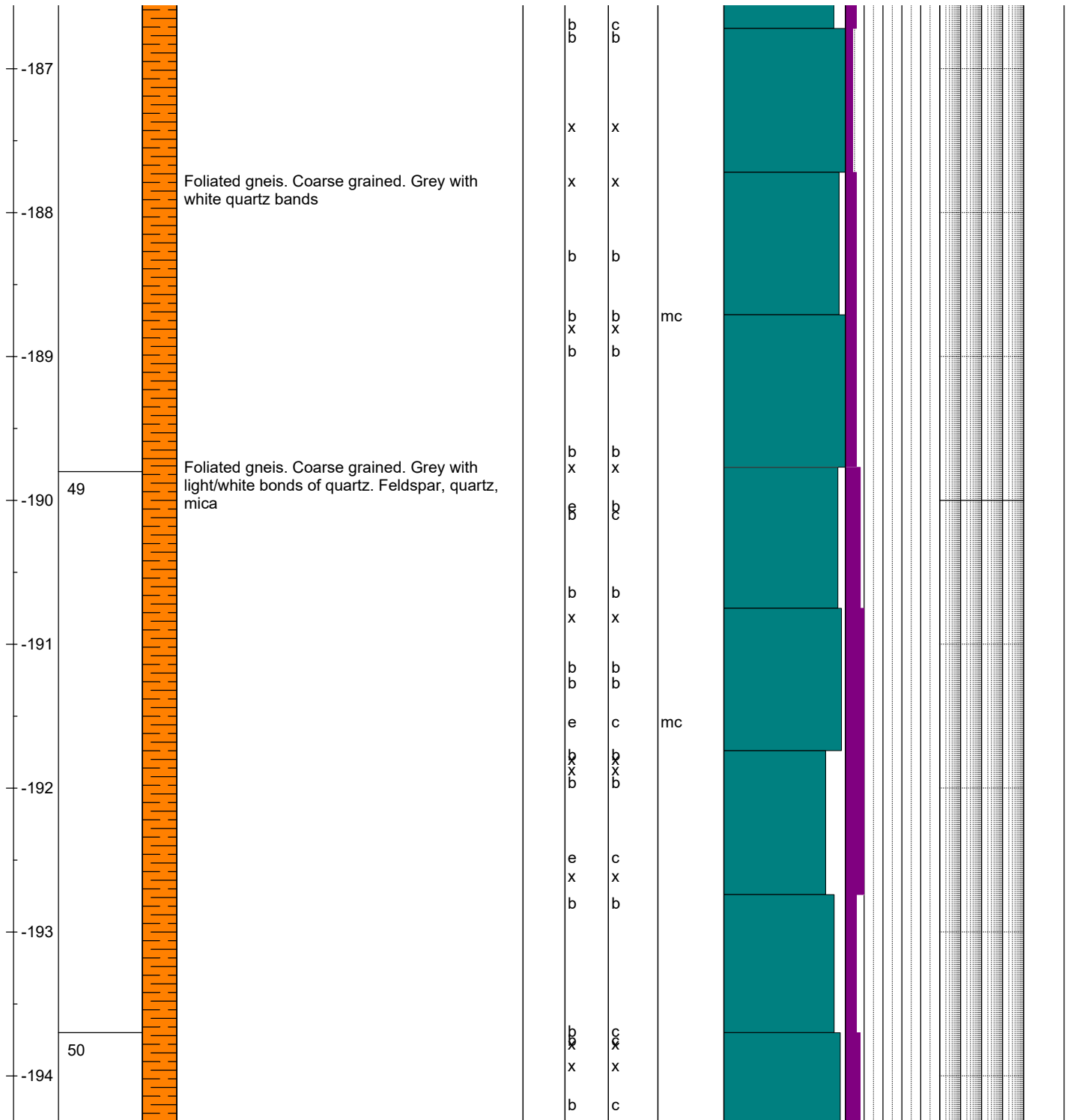
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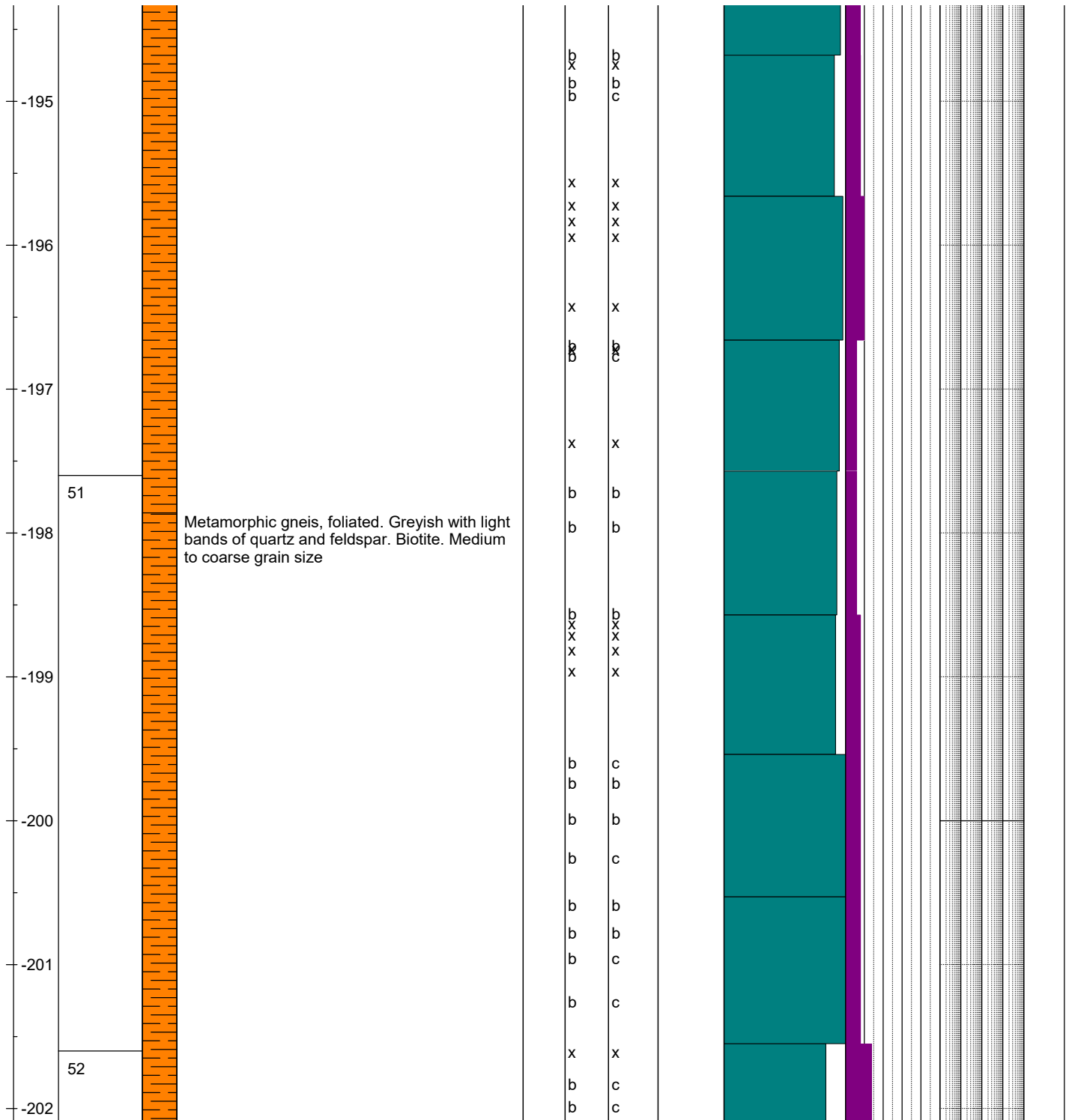
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								20 40 60 80	5 10 15 20	1 10 100	







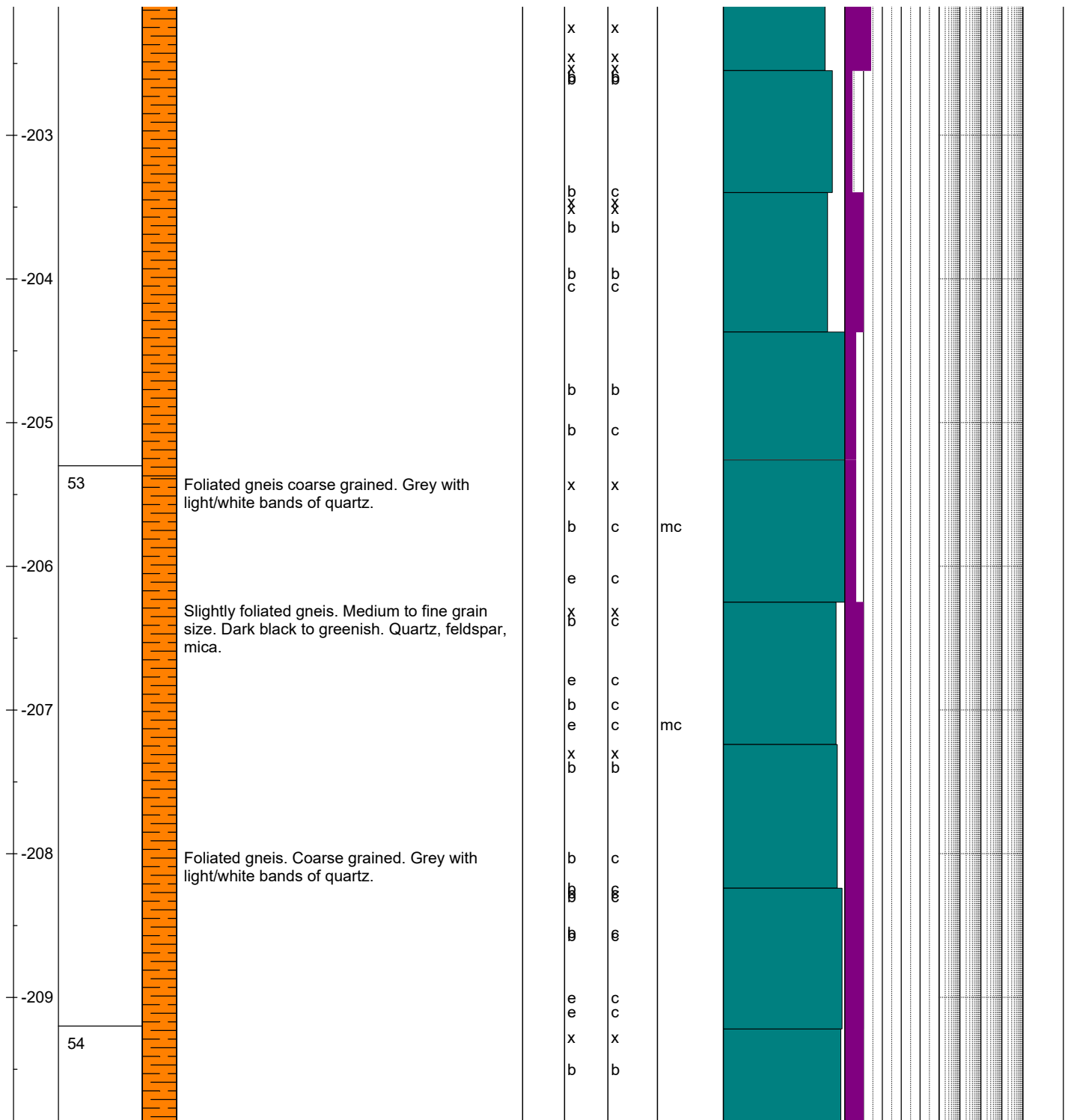
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								20	40	60	80		5	10	15	







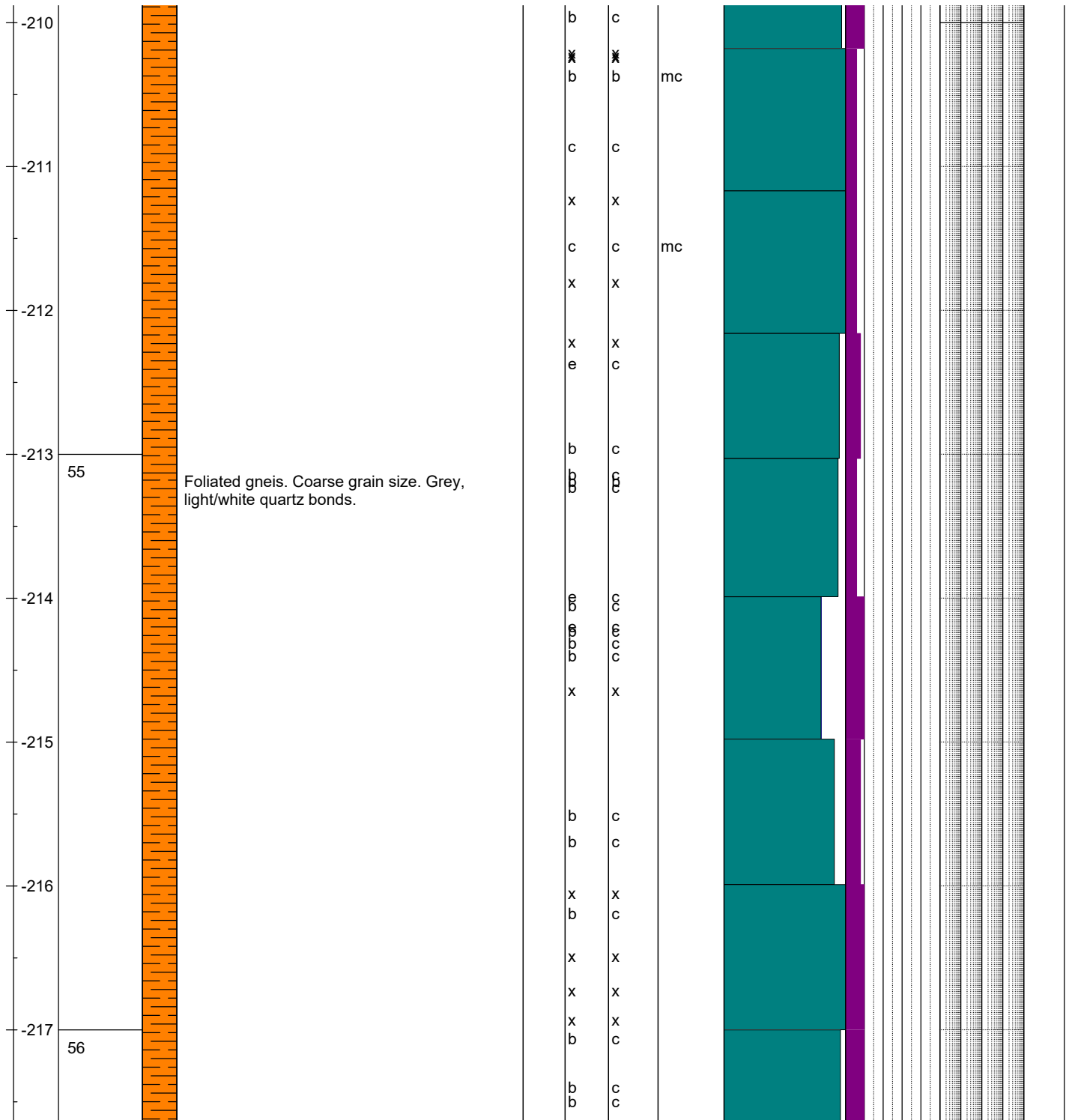
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								20 40 60 80	5 10 15 20	1 10 100	







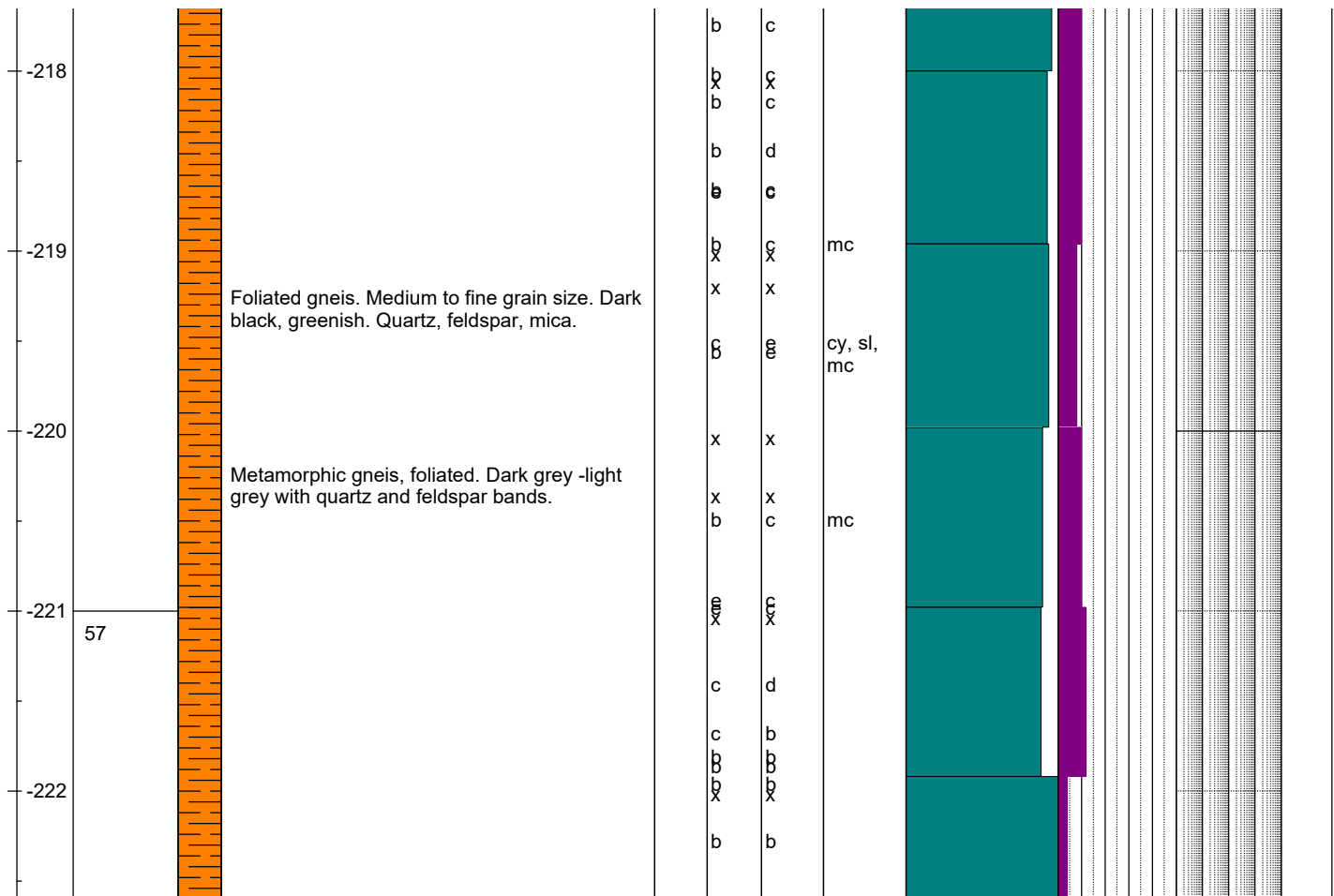
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								20 40 60 80	5 10 15 20	1 10 100	



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								20	40	60	80		1	10	100	



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								20	40	60	80		1	10	100	



Appendix C

PICTURES OF CORES KH-01-2018

Contents

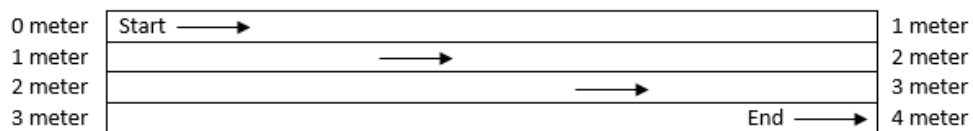
C1	Pictures of cores KH-01-2018	2
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C1 Pictures of cores KH-01-2018

Table 1. Overview of case no. and core length in KH-01-18.

Case no.	From	To	Length	Case no.	From	To	Length
	0	1	1	31	119,1	122,9	3,9
1	1,0	5,0	4,0	32	122,9	126,8	3,9
2	5,0	9,0	4,0	33	126,8	130,7	3,9
3	9,0	13,0	4,0	34	130,7	134,6	3,9
4	13,0	16,7	3,6	35	134,6	138,5	3,8
5	16,7	20,6	3,9	36	138,5	142,5	4,0
6	20,6	24,5	4,0	37	142,5	146,5	4,0
7	24,5	28,7	4,2	38	146,5	150,3	3,8
8	28,7	32,8	4,1	39	150,3	154,2	3,9
9	32,8	37,0	4,2	40	154,2	158,2	4,0
10	37,0	41,1	4,1	41	158,2	162,1	3,9
11	41,1	44,9	3,8	42	162,1	166,3	4,2
12	44,9	48,8	3,9	43	166,3	170,2	4,0
13	48,8	52,6	3,9	44	170,2	173,9	3,7
14	52,6	56,3	3,7	45	173,9	177,9	4,0
15	56,3	60,2	3,9	46	177,9	181,8	3,8
16	60,2	64,2	4,0	47	181,8	185,7	4,0
17	64,2	68,1	3,9	48	185,7	189,8	4,1
18	68,1	71,9	3,9	49	189,8	193,7	3,9
19	71,9	75,9	4,0	50	193,7	197,6	3,9
20	75,9	79,8	3,9	51	197,6	201,6	4,0
21	79,8	83,8	4,0	52	201,6	205,3	3,7
22	83,8	87,9	4,1	53	205,3	209,2	4,0
23	87,9	91,7	3,8	54	209,2	213,0	3,8
24	91,7	95,6	3,9	55	213,0	217,0	4,0
25	95,6	99,5	3,9	56	217,0	221,0	4,0
26	99,5	103,3	3,8	57	221,0	222,6	1,6
27	103,3	107,2	3,9				
28	107,2	111,2	4,0				
29	111,2	115,1	3,9				
30	115,1	119,1	4,0				

Note: Case direction is from upper left to lower right as shown on figure:



K1



K2



K3



K4



K5



K6



K7



K8



K9



K10



K11



K12



K13



K14



K15



K16



K17



K18



K19



K20



K21



K22



K23



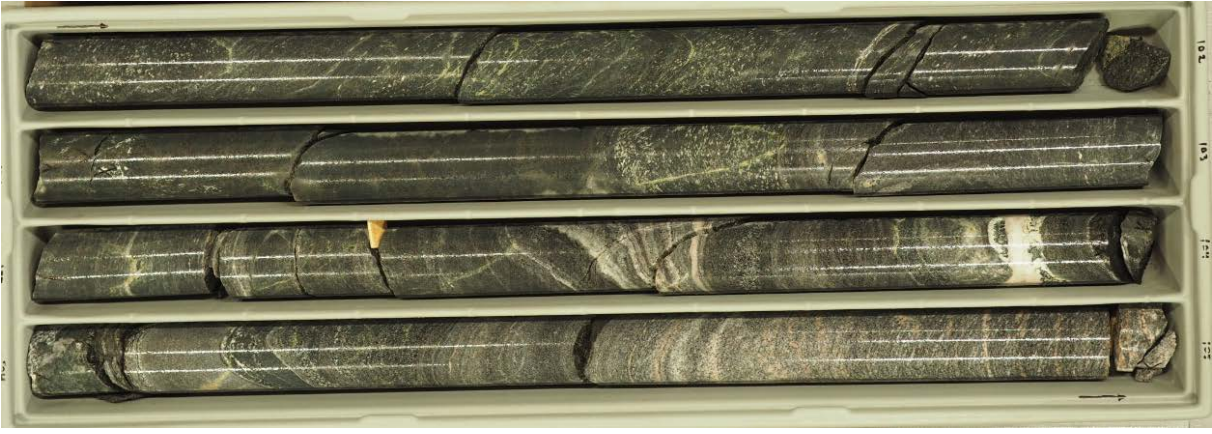
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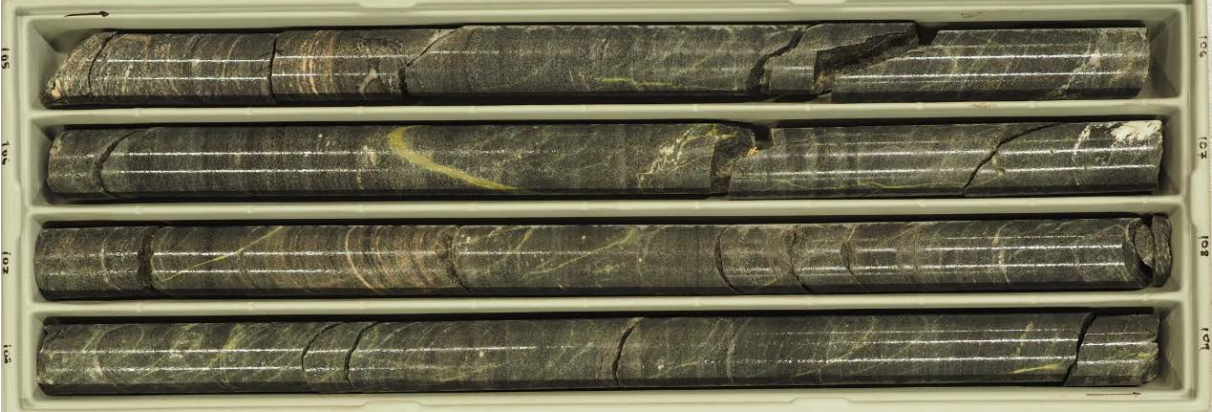
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K26



K27



K28



K29



K30



K31



K32



K33



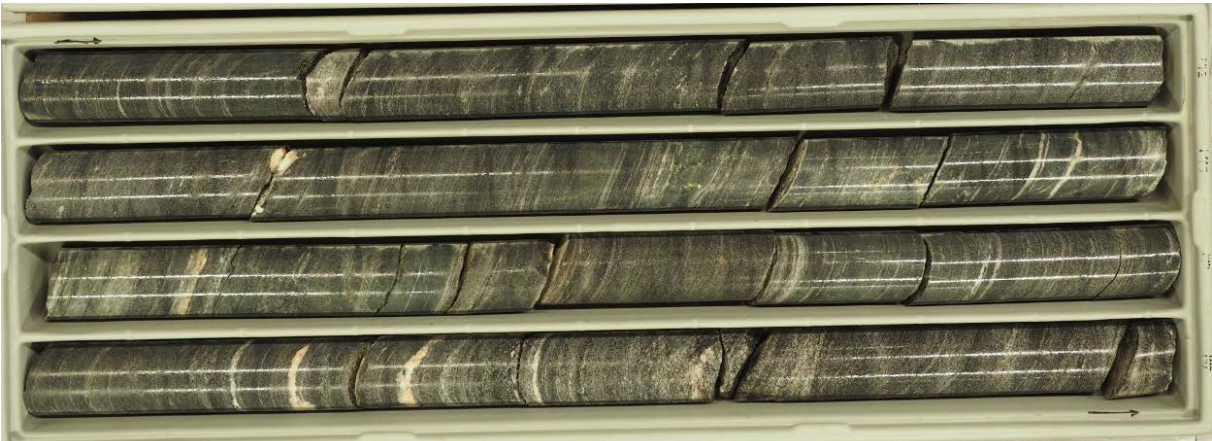
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K37



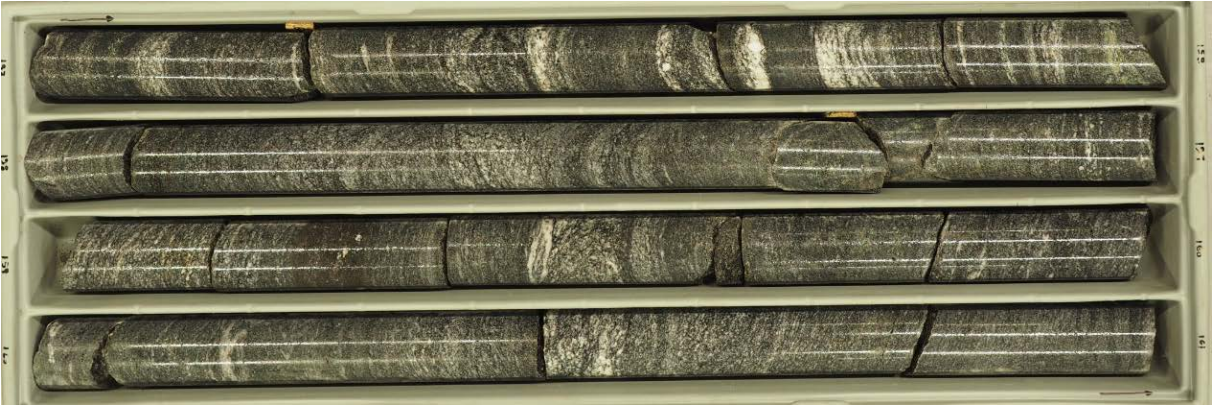
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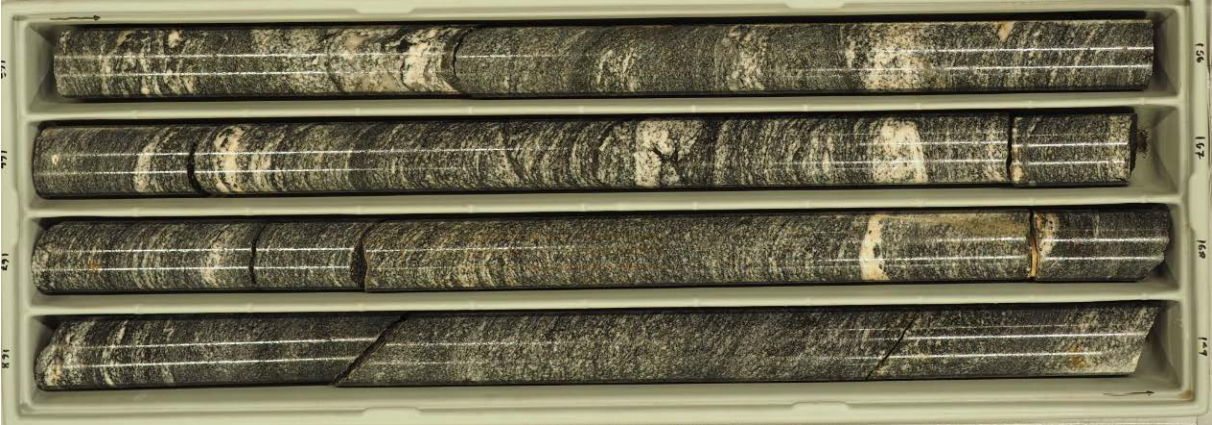
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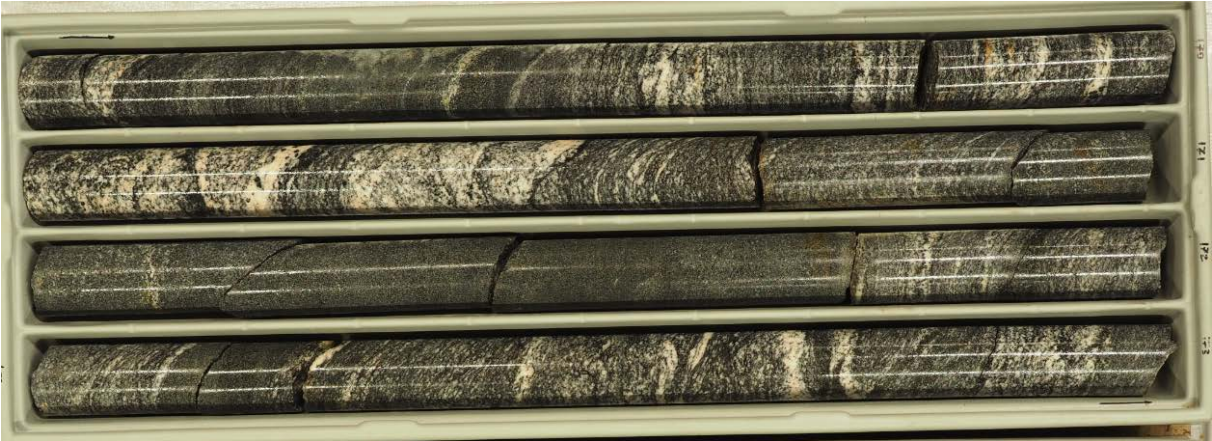
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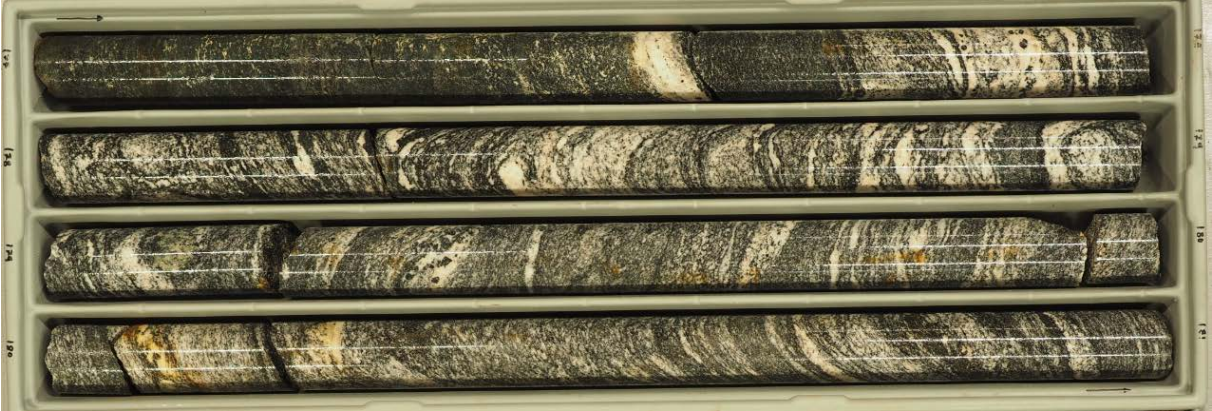
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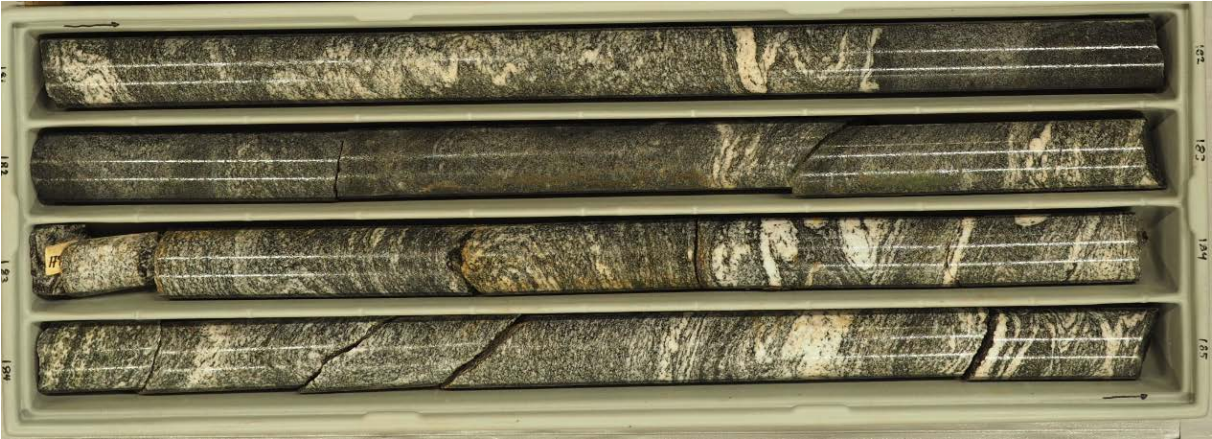
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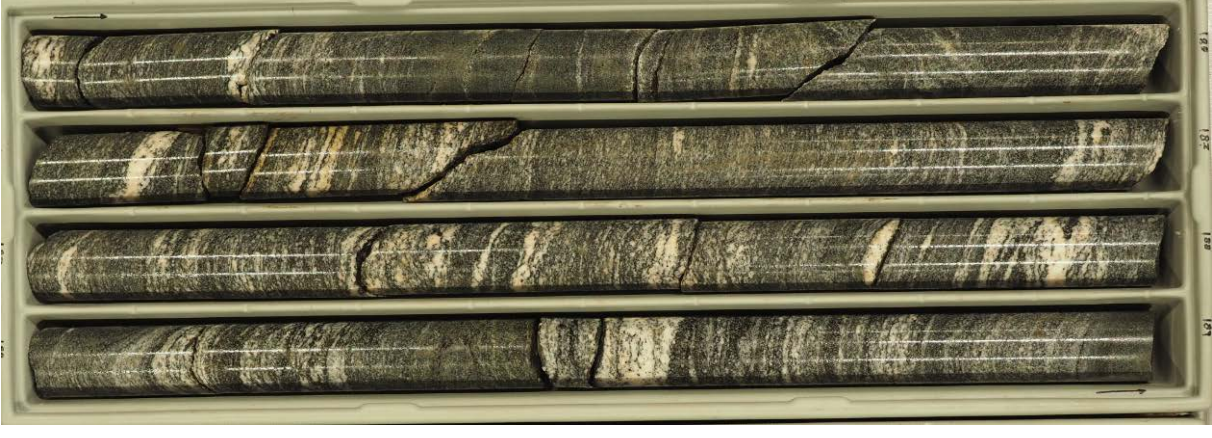
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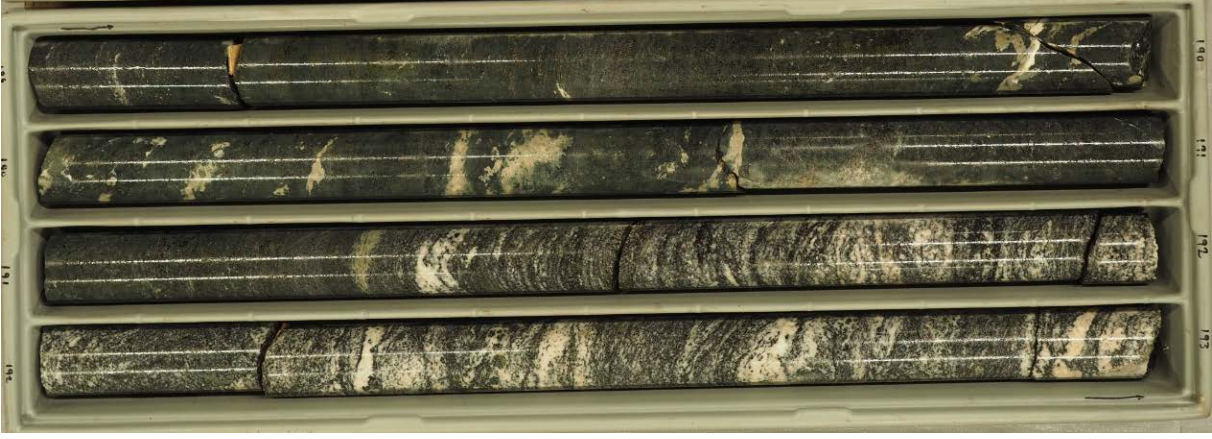
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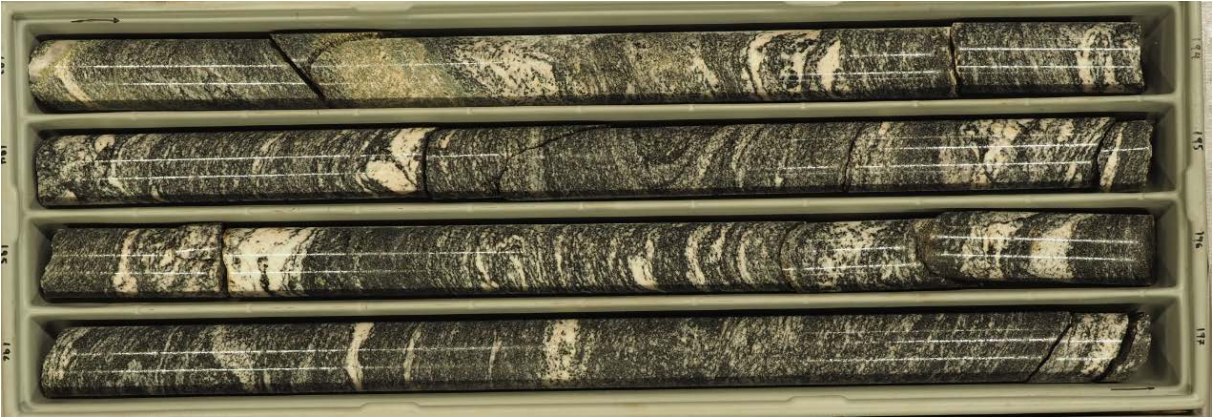
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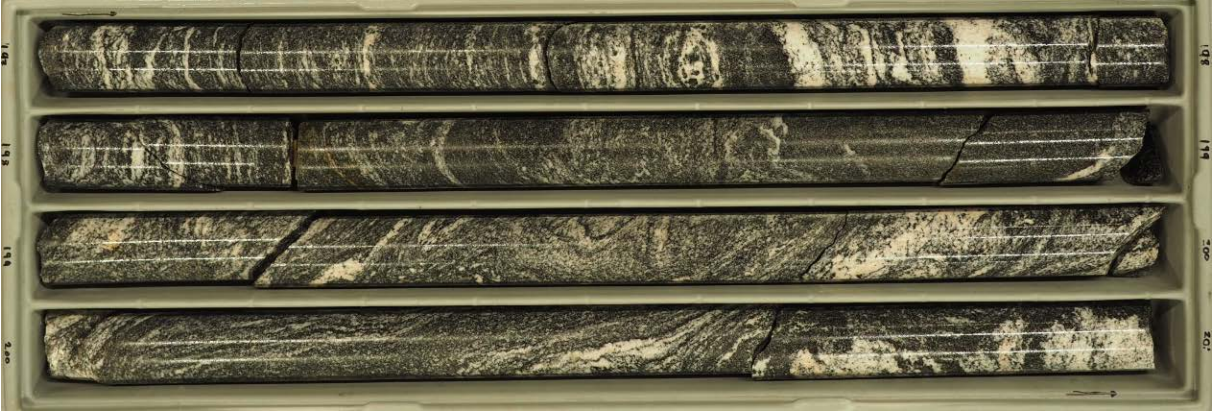
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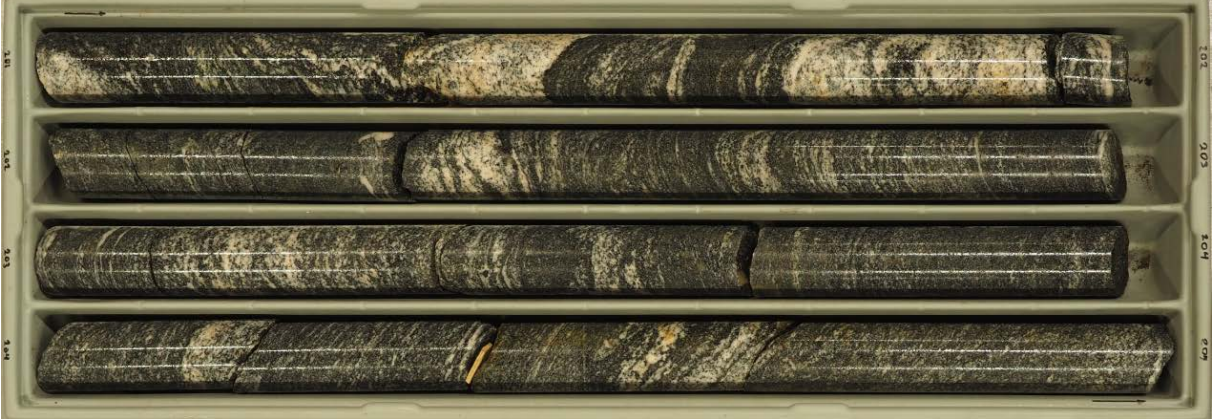
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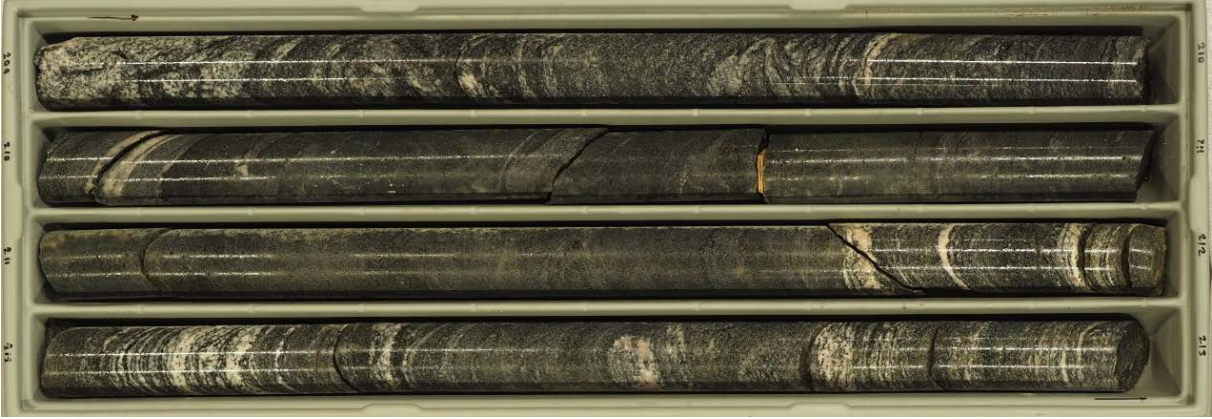
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K53



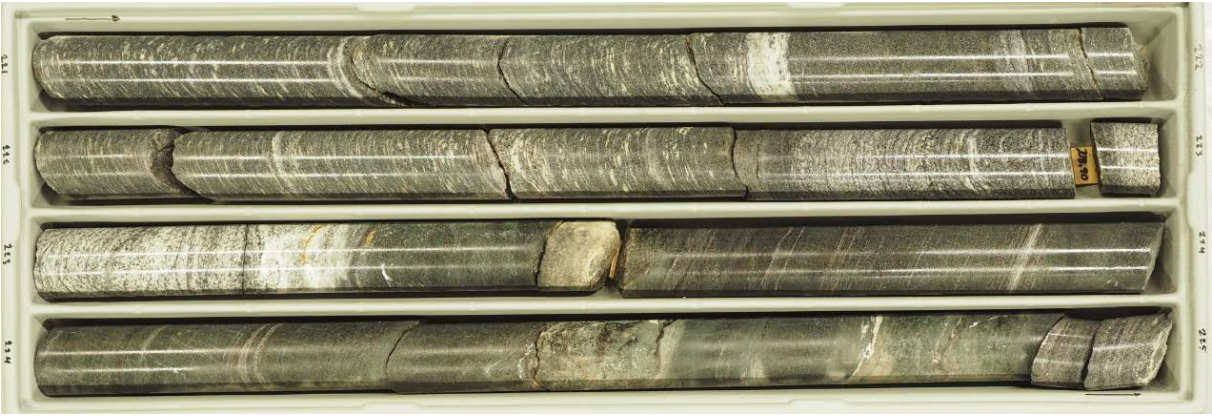
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K55



K56



K57



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Kommune/Municipality Stranda	Feltnavn/Field name
Sted/Location Åknes	Sted/Location
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NGI (Norwegian Geotechnical Institute) is a leading international centre for research and consulting within the geosciences. NGI develops optimum solutions for society and offers expertise on the behaviour of soil, rock and snow and their interaction with the natural and built environment.

NGI works within the following sectors: Offshore energy – Building, Construction and Transportation – Natural Hazards – Environmental Engineering.

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