ORKUSTOFNUN

NATIONAL ENERGY AUTHORITY

HÓLMSBERG

Boreholes B-9 and B-10

Skúli Víkingsson and
Snorri Zóphóníasson

OS82092/VOD40 B

October 1982

ORKUSTOFNUN
GRENSÁSVEGI 9, 108 REYKJAVÍK

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1.0 INTRODUCTION

The work described in this report was carried out in accordance with a contract between Orkustofnun and AV Consulting Engineers (Almenna verkfræðistofan), dated September 17 1982, in connection with the proposed oil storage and harbor project at Hólmsberg and Helguvík South West Iceland.

The work included:

(1) Core drilling. Two boreholes, B-9 and B-10, were drilled, 21.6 and 20.9 m. For location see Fig. 2.

(2) Core logging: (a) General geological logging of the cores. Graphic core logs are shown in Fig. 4. (b) Rock mass quality classification after the NGI*) Q-system.

In accordance with the contract the work was performed in the same way as the earlier work in the same area as described by Víkingsson & Kristinsson (1982), but some additions were made concerning armor rock aspects.

2.0 STRUCTURE

All the rocks penetrated by the boreholes belong to the same compound lava flow, which is made of many flow-units of different thicknesses. Each flow-unit usually lies directly on top of another unit but interbedded scoria occurs, although not penetrated by any of the 10 boreholes. The rock type is olivine tholeiite. One thick flow-unit which commonly exceeds 25 m in thickness, comprises the top of most of the cliffs and is penetrated by the boreholes. This flow unit is often of a multiple character, that is cooling cracks extend through a horizontal boundary or a weakness zone. In B-9 it is 14 m thick but 17 m in B-10.

No tectonic fractures have been observed in the cliff sections. The joints found are in most cases easily recognised as either more or less vertical cooling cracks or nearly horizontal weakness zones. The interval between cooling cracks is proportional to the thickness of the flow-unit.

3.0 TEXTURE

The texture of the basalts is typical for olivine tholeiites with large crystals compared with basalt in general. Plagioclase, olivine and even pyroxene (augite)

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*) Norwegian Geotechnical Institute

crystals are commonly visible to the naked eye. The crystal matrix is loosely constructed with voids between crystals, a feature generally thought to be caused by degassing of the crystallizing melt.

4.0 CORRELATIONS

Correlations of contacts between flow-units can only be done across quite short distances. Thus no certain correlations can be made between the two holes or between them and the previously drilled holes and the sections. The thick flow-unit next to surface in both of these holes is probably the same as that exposed in the cliffs next to them (see section E-E, Fig. 3).

5.0 ROCK MASS QUALITY

Rock quality analyses were carried out for the core in both of the holes, i. e. B-9 and B-10, in the same way as described in the previous report (Víkingsson & Kristinsson 1982). Following are the changes made on the NGI-system concerning basalt (of the kind in the Hólmsberg area), and the reasons for the numbers given to each parameter.

RQD: Recovery of core pieces $\geq$ 10 cm long.

Jn: The number 9 has been agreed upon for medium and large columnar basalts such as we are dealing with at Hólmsberg until further experience permits reevaluation.

Jr: This is determined by taking the average of the numbers in the Jr column (gerð/type) and add 0.5. This should compensate for the fact that when basalt is observed in an exposure many discontinuous joints are found whose discontinuous nature is not recognised in a core. Time will tell if 0.5 is the correct figure.

Ja: Here the number 1.0 was used for all the holes according to the NGI-system. This basalt is a typical late Quaternary lava in the respect that the joint walls are unaltered and contain only surface staining, but no particularly problematic minerals.

Jw: Since all the holes are dry for the top 15 meters the number 1.0 was given everywhere according to the NGI-system.

SRF: The number 2.5 has been chosen here as the most suitable on a regional scale, according to the NGI-system, even though no stress measurements have been made. Regional stress measurements are not considered necessary under these obviously low stress conditions. However the number 5.0 is more suitable when referring to each single basalt column i. e. local failures, with the result of 50% lowering of each Q-value in Table 2.

Table 2 shows Q values for each drillhole (B-1 to B-10) and the factors it is made of. The placing of each Q value on the NGI tunnel support chart (Barton & al. 1974) is shown in a diagram below Table 2. The joint analysis charts of holes B-9 & B-10 make up Appendix 1. The legend for the rock quality analyses is also in Appendix 1. This is mostly based on Barton et al. 1974 and also on experience with Icelandic rock formations.

The equivalent dimension refers to an open circular pit of 50 meters in diameter. The ESR (excavation support ratio) value is estimated to be between 2.5 and 5, giving the equivalent dimension a value between 10 and 20.

The core was given two Q values for each of the boreholes. Of the 4 Q values obtained, 2 were fair/good (the upper parts of the holes) and 2 were poor/fair (the lower parts).

The rock quality analyses data for these two holes are quite similar to the data for the previously drilled holes (Víkingsson & Kristinsson 1982).

6.0 ARMOR ROCK ASPECTS

When the core logging was almost finished, we got an inkling that the main purpose of the core drilling was to locate a feasible armor rock quarry. It is therefore right to point out that a rock mass quality analysis of the kind we have performed gives little information about the quality of the rock for this purpose. The purpose of the system used is to analyse rock stability for tunnels and other excavations. Therefore we also measured the RQD50 value, that is recovery of core pieces larger than 50 cm compared to 10 cm for the common RQD. The RQD50 values are listed on a special column on the graphic core logs (Fig. 4) to the right of the RQD-column.

Armored rock used with good results in the neighboring harbors (Njarðvík and Sandgerði) is quarried from the same kind of rocks as in the Hólmsberg area. Problems which have occurred have to do with the heterogeneity of the compound structure of the lava. The maximum sizes of blocks which can be quarried from the rock depend on the column sizes, which again depend on the thickness of the flow-unit. As can be seen in the Hólmsberg cliff section (see Víkingsson & Kristinsson 1982) the irregularities are striking. As mentioned above, one thick flow-unit which commonly exceedes 25 m in thickness, comprises the top of most of the cliffs and is penetrated by the boreholes. (In B-9 it is 14 m thick but 17 m in B-10).

In both of the two rock quarries named above, thick flow-units giving large blocks grade into many thin flow-units and consequently the maximum sizes of blocks decreases. So the direction of the quarrying was modified as it proceeded. Guðmundsson (1982) recommends grid core drilling for a detailed location of a quarry in these rocks.

Table 3 shows dry volume weight, density and porosity data for specimens from Hólmsberg (B-9 and B-10), the breakwater and the rock quarry of Njarðvík harbor, and from the rock quarry in Sandgerði.

Ten samples from borehole B-6 gave the mean point load strength value of 2.8 MPa, which corresponds to 61.2 MPa uniaxial strength.

Tests made on rocks from the two quarries (Njarðvík and Sandgerði) have in general given good results (Harðarson 1979) except the Los Angeles abrasion test showed little abrasion resistance. The values for uniaxial strength are 42-72 MPa. 300 frost-thaw cycles did not have a detectable effect on the 3 specimens tested.

REFERENCES

Barton, N.; Lien, R. & Lunde, J. 1974: Engineering classifications of rock masses for design of tunnel report. Rock Mechanics, Vol. 6, p.p. 189-236.

Guðmundsson, Ágúst 1982: Tillögur um grjótnám við Helguvík. Almenna verkfræðistofan, júní 1982.

Harðarson, Björn A. 1979: Rannsóknir á íslensku basalti med tilliti til notkunar í grjótvarnir. (Unpublished thesis).

Víkingsson, Skúli & Kristinsson, Bjarni 1982: Hólmsberg. Geological report. Orkustofnun OS82042/VOD25 B, May 1982.

TABLE 1

COORDINATES OF BOREHOLES

NAME	X	Y	EL.
B-1	723230.68	399929.18	26.19
B-2	723317.56	400057.15	25.08
B-3	723327.09	400363.30	27.00
B-4	723088.61	400128.83	25.87
B-5	723031.95	399922.52	27.71
B-6	722657.89	399482.35	25.00
B-7	722587.94	399307.10	23.09
B-8	722725.30	399324.28	23.88
B-9	723262.50	400515.14	28.96
B-10	723419.24	400750.36	28.07

Coordinates: Lambert

TABLE 2

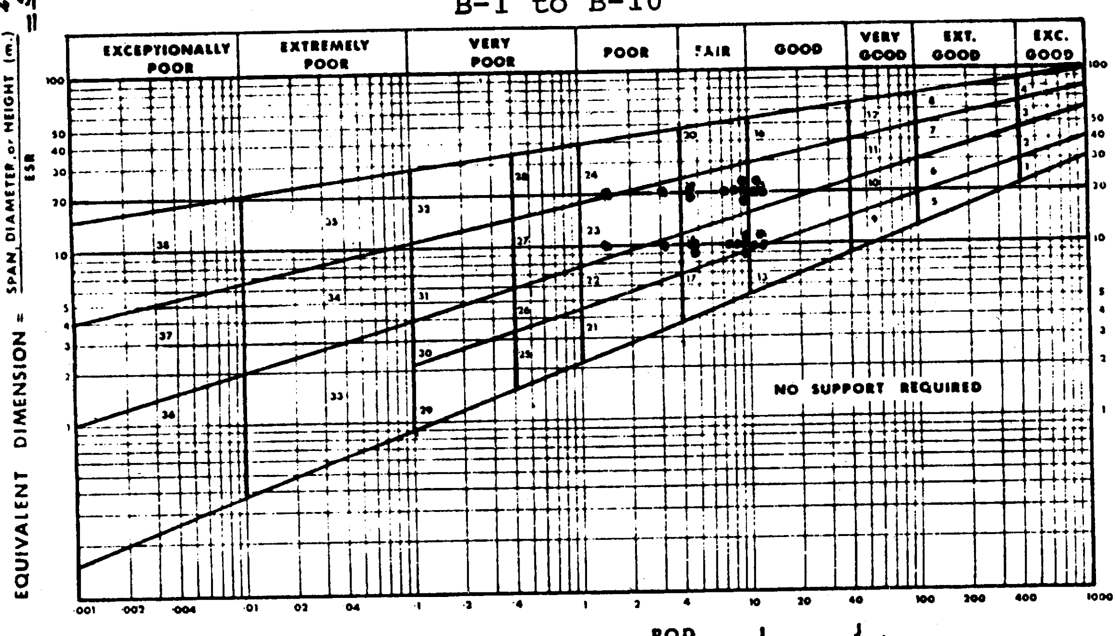
Rock quality according to the NGI-system

Hole	m el.	m depth	RQD:Jn	Jr:Ja	Jw:SRF	Q
B-1	23.4-20.0	2.85- 6.15	40:9	2.6:1	1:2.5	4.6
"	20.0-11.0	6.15-15.15	98:9	2.4:1	1:2.5	10.4
B-2	22.8- 9.9	2.25-15.20	79:9	2.4:1	1:2.5	8.4
B-3	25.3-11.8	1.70-15.15	91:9	2.8:1	1:2.5	11.3
B-4	24.4-13.4	1.50-12.50	90:9	2.3:1	1:2.5	9.2
"	13.4-10.6	12.50-15.30	30:9	2.3:1	1:2.5	3.1
B-5	26.5- 8.8	1.20-18.95	96:9	2.7:1	1:2.5	11.5
B-6	23.6-21.5	1.45- 3.50	52:9	1.9:1	1:2.5	4.4
"	21.5- 9.8	3.50-15.15	94:9	1.8:1	1:2.5	7.5
B-7	22.2- 5.2	0.85-17.90	91:9	2.3:1	1:2.5	9.3
B-8	23.5- 5.9	0.40-15.90	85:9	2.6:1	1:2.5	9.8
B-9	23.9-14.9	5.1 -14.1	90:9	2.6:1	1:2.5	10.4
"	14.9- 7.4	14.1 -21.6	48:15	3.5:1	1:2.5	4.5
B-10	25.8-10.8	2.3 -17.3	90:9	2.4:1	1:2.5	9.6
"	10.8- 7.3	17.3 -20.8	20:15	3.5:1	1:2.5	1.5

$\frac{50}{2.5} = 20$ $\frac{50}{5} = 10$

Tunnel support chart showing 38 categoris of support which are determined by the tunneling quality (Q) and the equivalent dimension (D_e) of the excavation.

B-1 to B-10



TUNNELING QUALITY $Q = \left(\frac{RQD}{J_n}\right) \times \left(\frac{J_r}{J_a}\right) \times \left(\frac{J_w}{SRF}\right)$

TABLE 3

	DRY VOLUME WEIGHT kg/m3	DENSITY kg/m3	POROSITY
1. B-9 (6 m)	2690	2920	0.08
2. B-10 (18 m) *)	2380	2940	0.19
3. Njarðvík **)	2760	3050	0.09
4. Njarðvík ***)	2690	2990	0.10
5. Sandgerði ***)	2770	3010	0.08

*) Highly vesicular
**) Breakwater (2 specimens)
***) Rock quarry

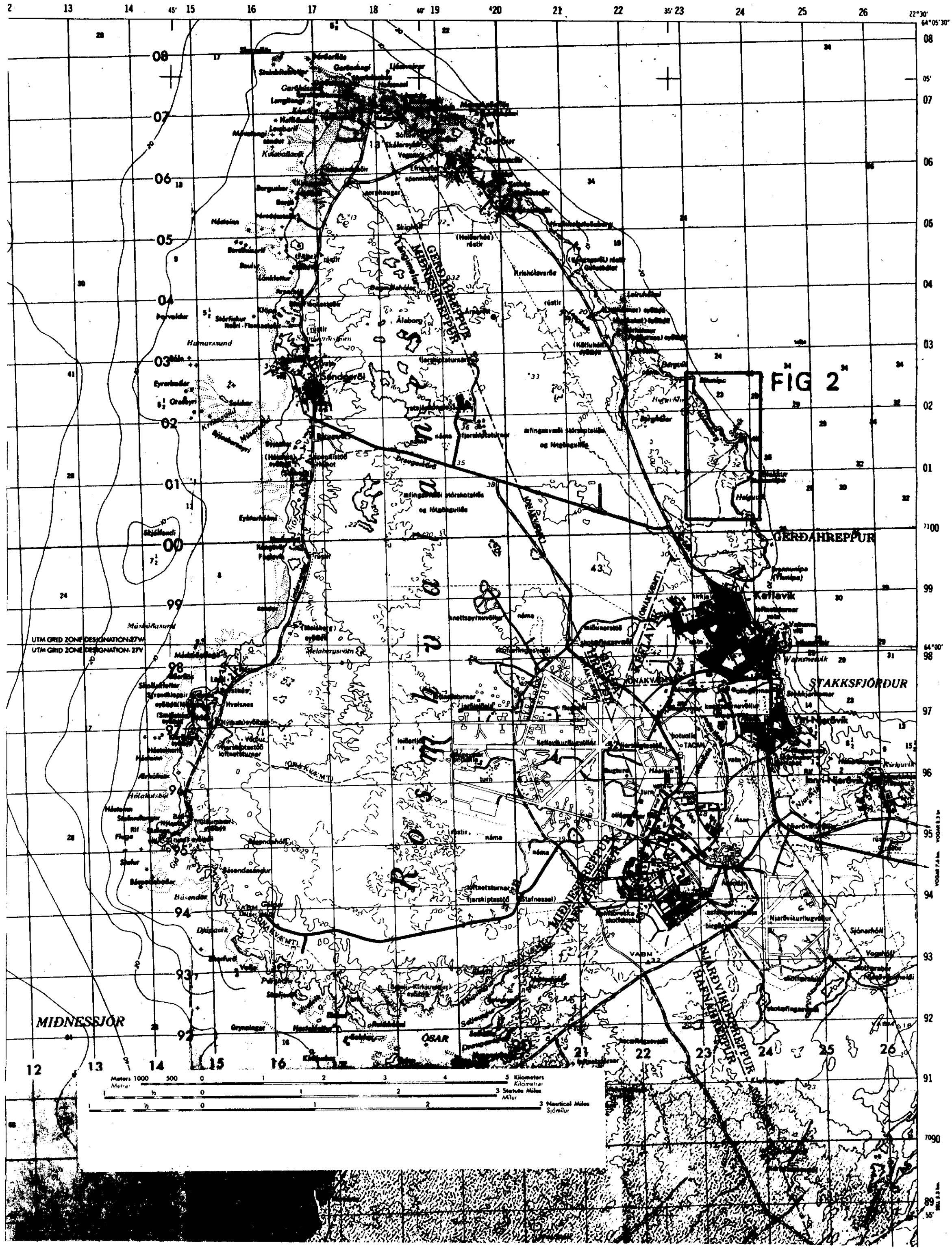


Fig. 1: Location map. (A part of Sheet 1512IV Keflavík published by Landmælingar Íslands (Icelandic Geodetic Survey) and DMAHTC U.S.A.).

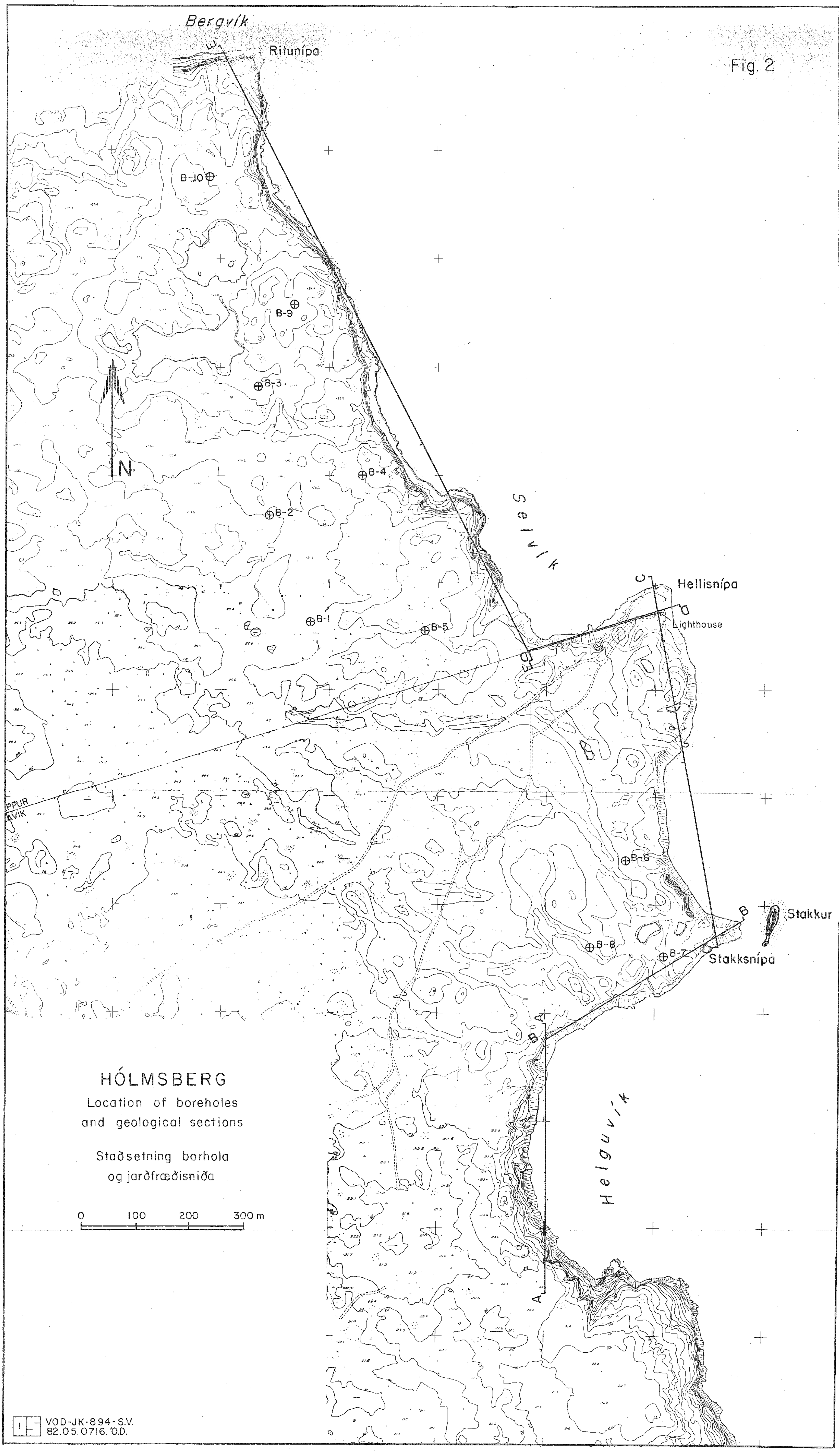
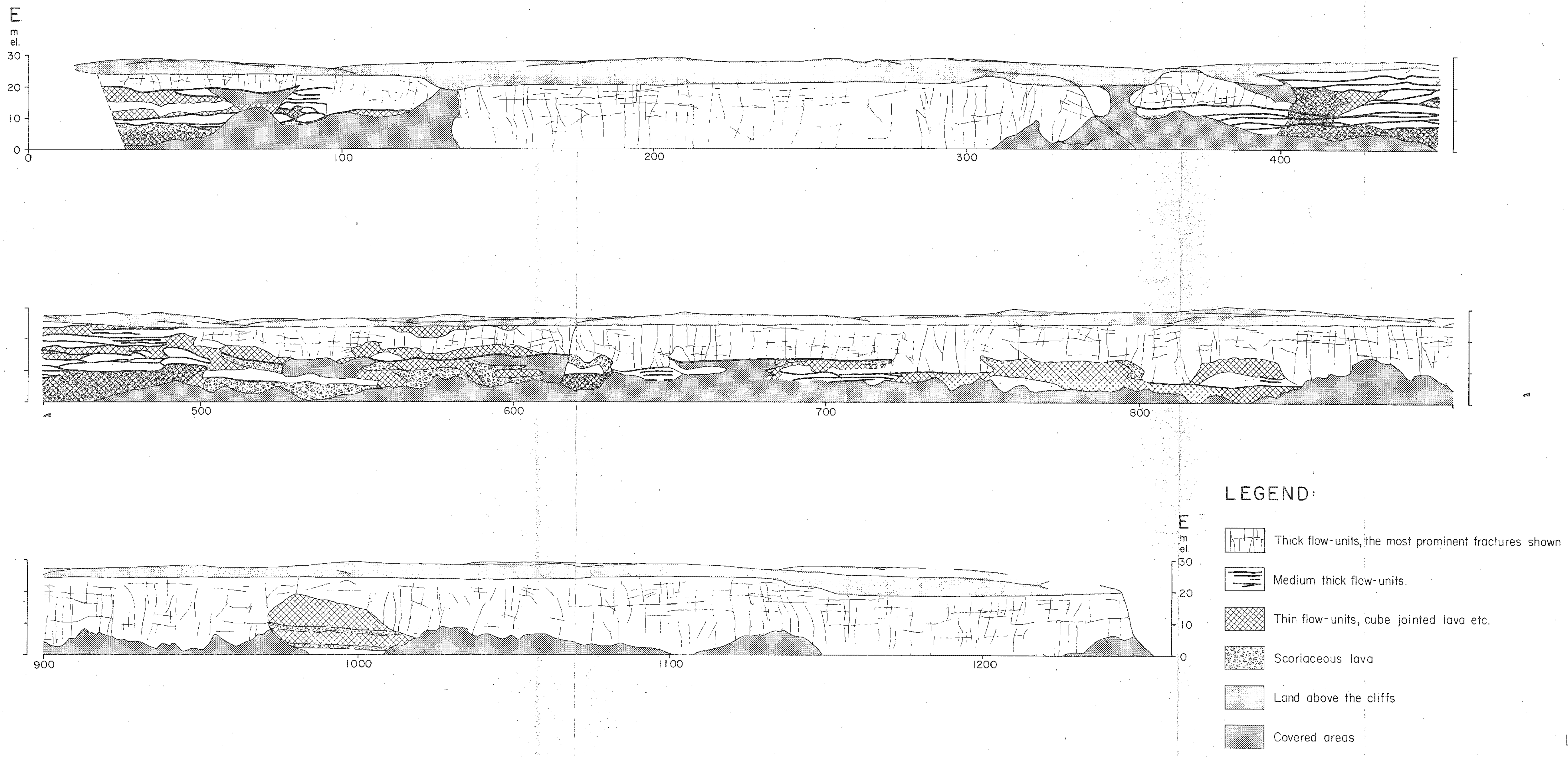

Bergvík
RituníPa
Fig. 2
B-10
B-9
B-3
B-4
B-2
B-1
B-5
N
Selvík
Hellisnípa
Lighthouse
B-6
Stakkur
B-8
B-7
Stakksnípa
Helguvík
HÓLMSBERG
Location of boreholes
and geological sections
Staðsetning borhola
og jarðfræðisniða
0 100 200 300 m
VOD-JK-894-S.V.
82.05.0716. O.D.

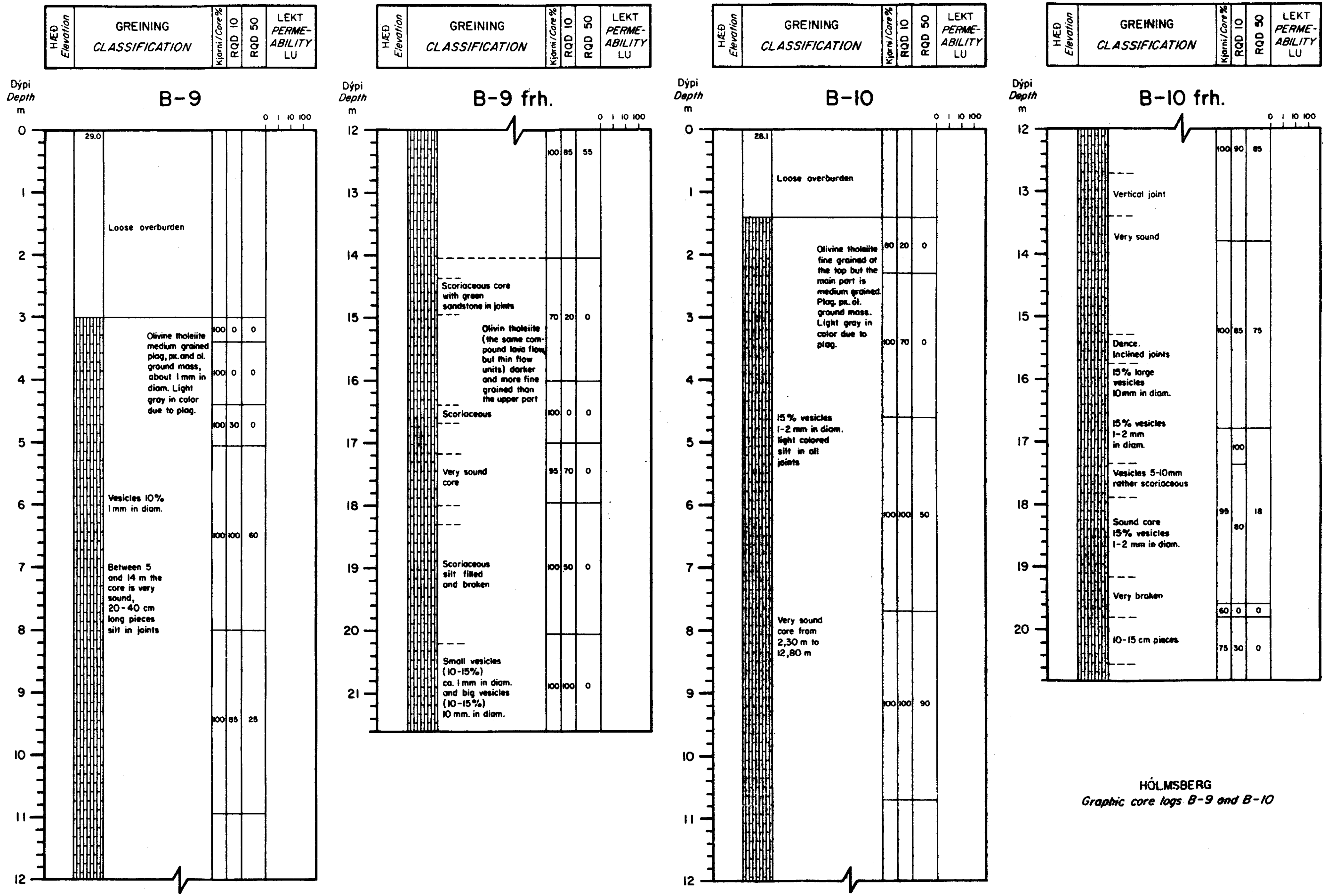
Fig. 3



Location see fig. 2

VOD-JK-894-S.V.
82.04.0661 'OD

Fig. 4



HÓLMSBERG
Graphic core logs B-9 and B-10

VOD-MJ-894-SZ
82.10.1196-GSJ

APPENDIX 1

Rock mass quality

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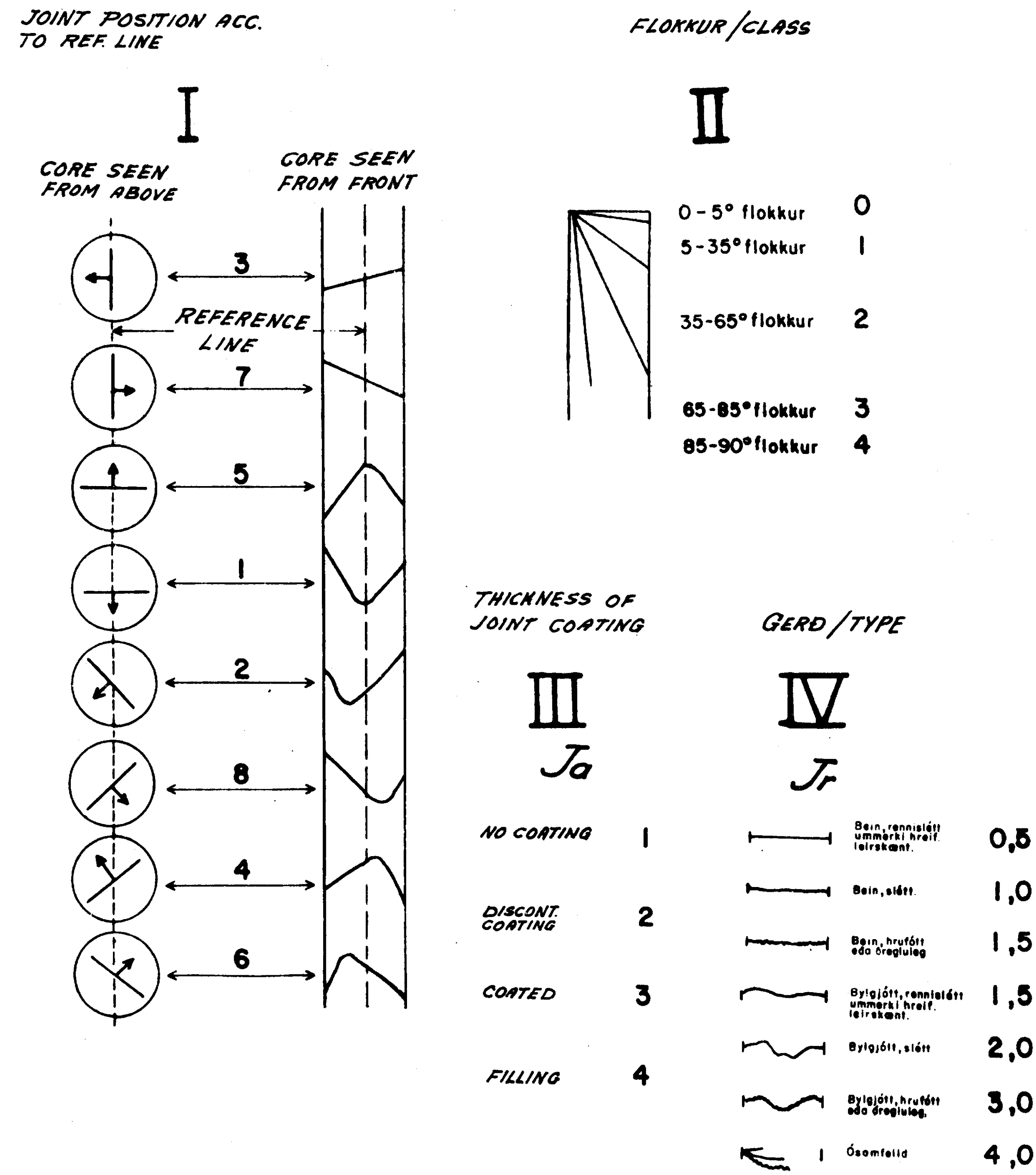
VOD-MJ-900 BAH
81.10.1240e

LEGEND FOR ROCK QUALITY ANALYSIS



VOD-MJ-900-BAH
81.06.0745 - EBF

SPRUNGUGREINING

STAÐUR / *Location*: Holmsberg
HOLA / *Borehole*: B-9
BORKRÓNA / *Drill Bit*: B?
DAGS. / *Date*: 05.10.82

HOLUHÆÐ / *Height of hole m.a.s.l.*:
BOR / *Drill rig*: Sullivan 4
DÝPI FRÁ / *Depth interval*: 3.0 TIL / *to*: 21.6 M / *m*

STEFNA HOLU / *Orientation of boreh.*: Lóðrétt
BLAÐ NR. / *Sheet no.*: 1 AF / *of*: 3
GREINT AF / *Logged by*: SZ + EP

Dýpi, m *Depth*	Kjarni % *Core*	RQD %	Sprungulýsing *Description of joints*	Lýsing jarðlaga *Classification*	RQD/Jn *betra/verra*	Jr/Ja *betra/verra*	Jw/SRF *betra/verra*	Q *betra/verra*
0–3								
3.0–3.4	100	0	>20 joints	Olivine tholeiite medium grained plag, px. and ol ground mass above 1mm in diam. Light gray in color due to plag	Veðrað útvorðurð,	engin einkunn gefin.		
3.4–4.4	100	0						
4.4–5.1	100	30						
5.1–8.0	100	100		vesicles 10% 1mm in diam. Between 5 and 14 m the core is very sound, 20-40 cm long pieces. Silt in joints	90/9	2.6/1	1/2,5	10,4
8.0–10	100	35						

Sprungur *Joints*	Flokkur *Class*	Fylling *Fill*	Gerð *Type*	Teg. fyll. *Type of fill*
2, 8	2/3	3/3	2/2	L L
2	2	2	2	LL
2	2	3	2	LL
4	3	4	2	LL
5	0	3	3	6r leir
2	2	3	1,5	6r leir
2	2	2	1,5	LL
6, 6	0, 1	2, 3	2, 2	LL, LL
6	2	2	2	LL
4	1	2	2	br L.
8, 4	0, 2	3, 2	2, 2	br L, LL
6	2	3	2	LL
8	3	3	2	
4, 4	3, 4	3, 3	2, 2	LL, LL

VOD-MJ-900-BAH
81.06.0745-EBF

SPRUNGUGREINING

STAÐUR / *Location*: Holmsberg — HOLA / *Borehole*: B 9 — BORKRÓNA / *Drill Bit*: BQ — DAGS. / *Date*: 05.10.82

HOLUHÆÐ / *Height of hole m.a.s.l.*: — BOR / *Drill rig*: Sullivan 4 — DÝPI FRÁ / *Depth interval*: 3.0 TIL / *to* 21.6 M / *m*

STEFNA HOLU / *Orientation of boreh.*: Lóðrétt — BLAÐ NR. / *Sheet no.*: 2 AF / *of*: 3 — GREINT AF / *Logged by*: SZ+EP

Dýpi, m / Depth	Sprungur / Joints	Flokkur / Class	Fylling / Fill	Gerð / Type	Teg. fyll. / Type of fill	Leiðarlína / Ref. line	Sprungulýsing / Description of joints	Sprungur á meter / Joints per meter	Kjarni % / Core	RQD %	Lekt Lu / Permeability	Hæð / Elevation m.y.s.	Snið / Column	Lýsing jarðlaga / Classification	Prófanir á sýnum og athugasemdir / Testing of samples and notes	RQD/Jn betra/verra	Jr/Ja betra/verra	Jw/SRF betra/verra	Q betra/verra
10.1	4	3	3	2	LL														
10.0–10.9									100										
10.9	4	4	2	3	LL														
11.2	2	3	3	2	LL														
11.95	8, 4	4, 4	3, 3	3, 2	LL, LL														
12.3	6, 2	3, 1	3, 3	2, 2	LL, LL														
12.55	6	3	3	2	LL														
12.7	8	3	3	2	LL														
10.9–14.1									100	85									
14.1–16.0							very broken	>10	70	20				Scoriaceous core with green sandstone in joints; Olivine tholeiite (the same compound lava flow but thin flow units) darker and more fine grained than the upper part		48/15	3.5/1	1/2.5	4.5
16.0–17.0								>>10	100	0				Scoriaceous					
17.0	0	3	2	2	LL														
17.0–17.9									95	70				Very sound core					
17.7	0	3	3	2	LL														
17.85	0	3	2	2	LL														
18.0	0	2	3	2	Kísill														
18.3–20.0							very broken	>10	100	50				Scoriaceous stle filled and broken					

VOD-MJ-900-BAH
81.06.0745 - EBF

SPRUNGUGREINING

STAÐUR / *Location*: Hólmsberg — HOLA / *Borehole*: B-9 — BORKRÓNA / *Drill Bit*: BQ — DAGS. / *Date*: 05.10.82

HOLUHÆÐ / *Height of hole m.a.s.l.*: — BOR / *Drill rig*: Sullivan 4 — DÝPI FRÁ / *Depth interval*: 3.0 — TIL / *to*: 21.6 M / *m*

STEFNA HOLU / *Orientation of boreh.*: Lóðrétt — BLAÐ NR. / *Sheet no.*: 3 — AF / *of*: 3 — GREINT AF / *Logged by*: SZ + GP

Dýpi, m *Depth*	Sprungur *Joints*	Flokkur *Class*	Fylling *Fill*	Gerð *Type*	Teg. fyll. *Type of fill*	Leiðarlína *Ref. line*	Sprungulýsing *Description of joints*	Sprungur á meter *Joints per meter* (0 2 4 6 8 10)	Kjarni % *Core*	RQD % (0 20 40 60 80)	Lekt Lu *Permeability* (0 1 10 100)	Hæð *Elevation* m.y.s.	Snið *Column*	Lýsing jarðlaga *Classification*	Prófanir á sýnum og athugasemdir *Testing of samples and notes*	RQD/Jn betra verra	Jr/Ja betra verra	Jw/SRF betra verra	Q betra verra
20														Small vesicles (10-15%) ca. 1mm in diam and big vesicles (10-15%) 10mm in diam					
21									100	100									
22																			

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SPRUNGUGREINING B-10

STAÐUR / Location: Holmsberg
HOLA / Borehole:
BORKRÓNA / Drill Bit: BQ
DAGS. / Date: 05.10.82
HOLUHÆÐ / Height of hole m.a.s.l.:
BOR / Drill rig: Sullivan 4
DÝPI FRÁ / Depth interval: 1.4 TIL / to 20.8 M / m
STEFNA HOLU / Orientation of boreh.: Lóðrétt
BLAÐ NR. / Sheet no. 1 AF / of 3
GREINT AF / Logged by: SZ + EP

Dýpi, m / Depth	Sprungur / Joints	Flokkur / Class	Fylling / Fill	Gerð / Type	Teg. fyll. / Type of fill	Sprungulýsing / Description of joints	Kjarni % / Core	RQD %	Lýsing jarðlaga / Classification	RQD/Jn	Jr/Ja	Jw/SRF	Q
1.4–2.3	0 0	0 3	1 3	2 2	LL	Very broken	80	20					
2.3–4.6	M 7 6 0 6 2 4 8 2 2 7 8 6 7	2 1 2 2 0 1 2 1 0 2 0 0 3 0	2 3 2 3 3 3 3 3 3 2 3 3 2 3	2 2 2 2 2 2 2 1,5 3 2 3 1,5 2 3	LL		100	70	Olivine tholeiite fine grained at the top but the main part is medium grained. plag px. ol groundmass Light gray in color due to plag 15% vesicles 1-2 mm in diam. light colored silt in all joints				
4.6–7.7	2 8 2 2 2 7 4	1 0 1 1 1 2 0	2 1 2 2 3 3 3	3 3 3 2 2 2 2	LL		100	100		90/9	2,4/1	1/2,5	9,6
7.7–10	2 6	1 2	2 3	3 2	LL LL		100	100	Very sound core from 2.3m to 12.8m				

VOD-MJ-900-BAH
81.06.0745 - EBF

SPRUNGUGREINING B-10

STAÐUR *Location*: Hólmsberg
HOLA *Borehole*:
BORKRÓNA *Drill Bit*: BQ
DAGS. *Date*: 05.10.82

HOLUHÆÐ *Height of hole m.a.s.l.*:
BOR *Drill rig*: Sullivan 4
DÝPI FRÁ *Depth interval*: 4,4
TIL *to*: 20,8 M *m*

STEFNA HOLU *Orientation of boreh.*: Lóðrétt
BLAÐ NR. *Sheet no.*: 2
AF *of*: 3
GREINT AF *Logged by*: SZ + BP

Dýpi, m *Depth*	Sprungur *Joints*	Flokkur *Class*	Fylling *Fill*	Gerð *Type*	Teg. fyll. *Type of fill*	Sprungulýsing *Description of joints*	Sprungur á meter *Joints per meter* (0 2 4 6 8 10)	Kjarni % *Core*	RQD % (0 20 40 60 80 100)	Lekt Lu *Permeability* (0 1 10 100)	Hæð *Elevation* m.y.s.	Snið *Column*	Lýsing jarðlaga *Classification*	Prófanir á sýnum og athugasemdir *Testing of samples and notes*	RQD / Jn (betra / verra)	Jr / Ja (betra / verra)	Jw / SRF (betra / verra)	Q (betra / verra)
10																		
11																		
12	4	1	3	2	LL			100	90									
	3	3	3	2	Br. Silc													
	8, 4	4, 3	1, 1	2, 2									Vertical joint					
13	2	4	2	2	LL													
													Very sound					
14																		
15	8	0	3	2	LL			100	85									
	3	0	2	2	LL													
	4, 4	3, 2	2, 3	2, 1,5	LL, LL								Dence. Inclined joints					
	4, 2, 8, 4	3, 2, 1, 0	1, 3, 1, 1	1,5, 1,5, 2, 1,5	LL													
	4, 5, 7, 3, 2, 2	2, 0, 0, 0, 2, 1	3, 1, 1, 1, 2, 1	2, 2, 2, 2, 2, 2	LL, LL								15% large vesicles 1-2 mm in diam					
16	4	3	1	3														
17									100				vesicles 5-10 mm rather scoriaceous					
	0	2	2	3	LL													
	0	2	3	2	LL													
18	0	1	2	1,5	LL	6 joints		95	80				Sound core 15% vesicles 1-2 mm in diam.		20 / 15	3,5 / 1	1 / 2,5	1,9
	0	0	2	2	LL													
19						Very broken							Very broken					
								60	0									
20									30									

VOD-MJ-900-BAH
81.06.0745 - EBF

SPRUNGUGREINING

STAÐUR *Location*: Hólmsberg — HOLA *Borehole*: B-10 — BORKRÓNA *Drill Bit*: BQ — DAGS. *Date*: 05.10.82

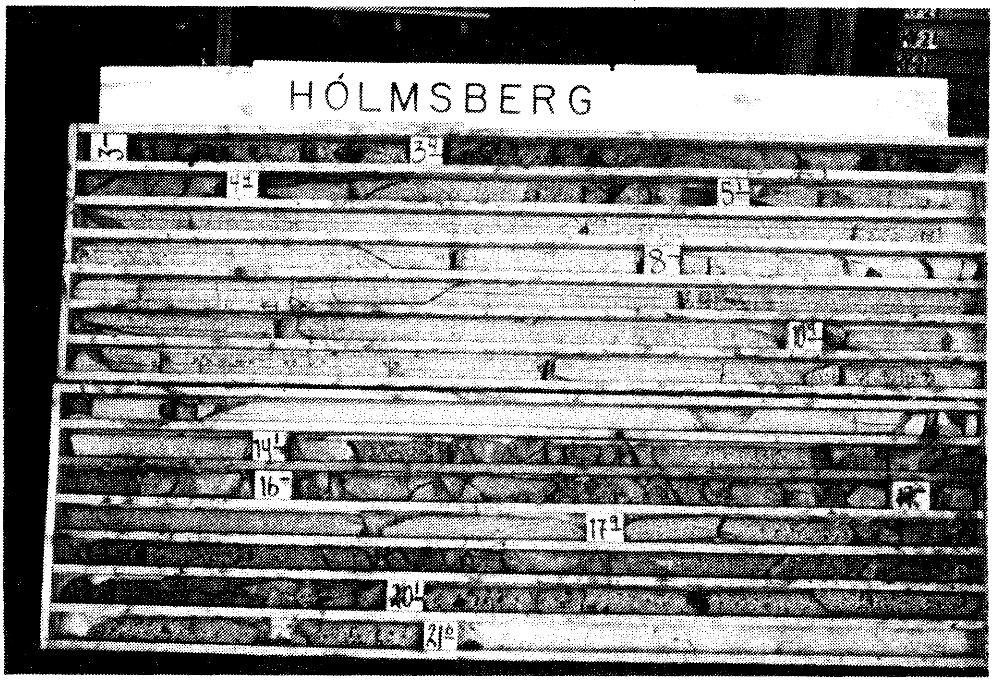
HOLUHÆÐ *Height of hole m.a.s.l.*: — BOR *Drill rig*: Sullivan 4 — DÝPI FRÁ *Depth interval*: 6.4 — TIL *to*: 20.8 M *m*

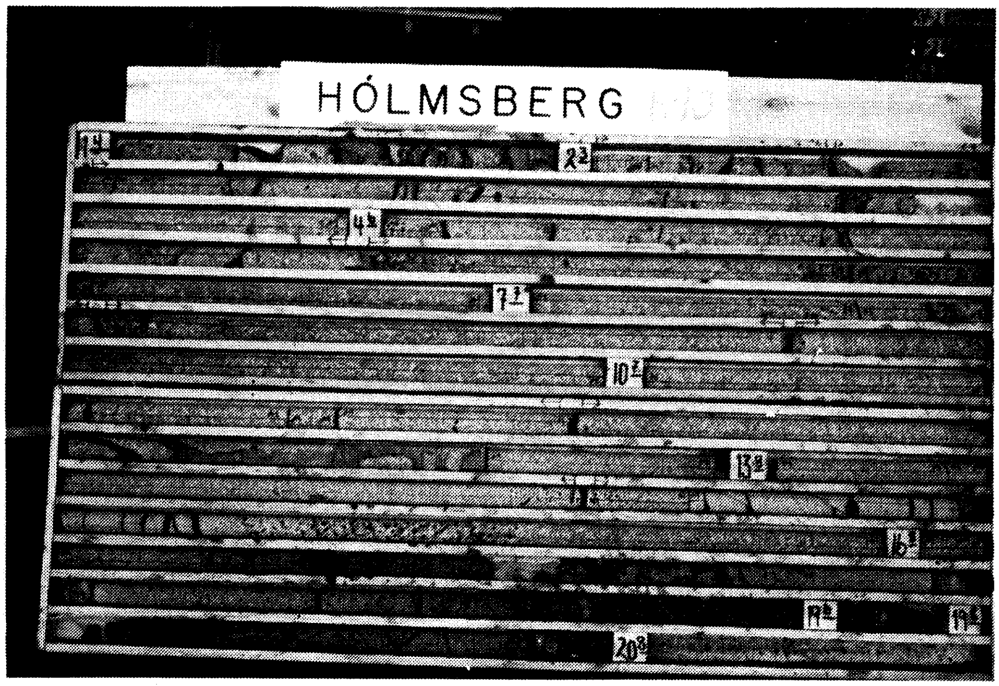
STEFNA HOLU *Orientation of boreh.*: Lóðrett — BLAÐ NR. *Sheet no.*: 3 — AF *of*: 3 — GREINT AF *Logged by*: EZ+EP

Dýpi, m *Depth*	Sprungur *Joints*	Flokkur *Class*	Fylling *Fill*	Gerð *Type*	Teg. fyll. *Type of fill*	Leiðarlína *Ref. line*	Sprungulýsing *Description of joints*	Sprungur á meter *Joints per meter* (0 2 4 6 8 10)	Kjarni % *Core*	RQD % (0 20 40 60 80)	Lekt Lu *Permeability* (0 1 10 100)	Hæð *Elevation* m.y.s.	Snið *Column*	Lýsing jarðlaga *Classification*	Prófanir á sýnum og athugasemdir *Testing of samples and notes*	RQD/Jn betra verra	Jr/Ja betra verra	Jw/SRF betra verra	Q betra verra
20										30									
21																			

APPENDIX 2

Core photographs


HÓLMSBERG


HÓLMSBERG