NGU Report 2007.020

Logging of drill cores from seven boreholes at Åknes, Stranda municipality, Møre and Romsdal County

NGU
Norges geologiske undersøkelse
Geological Survey of Norway

Geological Survey of Norway
NO-7441 Trondheim, Norway
Tel.: 47 73 90 40 00
Telefax 47 73 92 16 20

REPORT

Report no.: 2007.020	ISSN 0800-3416	Grading: Open

Title:
Logging of drill cores from seven boreholes at Åknes, Stranda municipality, Møre and Romsdal County

Authors: Guri Venvik Ganerød, Guro Grøneng, Ingrid Buvarp Aardal and Vidar Kveldsvik	Client: Åknes/Tafjord-prosjektet
County: Møre og Romsdal	Commune: Stranda
Map-sheet name (M=1:250.000) Ålesund	Map-sheet no. and -name (M=1:50.000) Geiranger 1219 II
Deposit name and grid-reference: WGS 1984, UTM 32N. E 395800 N6895200	Number of pages: 222 Price (NOK): 250 Map enclosures:

Fieldwork carried out:	Date of report:	Project no.:	Person responsible:
Summer 2005 & 2006	10.03.2007	300601	Jan S. Rønning

Summary:

This report contains data from core logging of seven drill cores from boreholes at Åknes rockslide area, Stranda municipality, western Norway. Four boreholes were drilled in 2005 and the remaining three in 2006. Raw data from the core logging are compiled, without any interpretation. Graphs of fracture frequency (FF) and RQD from the logging are presented and compared from the different drill sites.

Samples are collected from the drill cores and recorded in the logs. Method descriptions for the sample analysis are described in the report. Samples of standard engineering testing, such as UCS, E-Module, Poisson's ratio, Brazil test and sound velocity, are performed after standard ISRM methods, and some results are included in the report.

Keywords:	Bedrock (Fjell)	Engineering geology (Ingeniørgeologi)
Rock failure (Fjellskred)	Core logging (Borehullslogging)	Core samples (Kjerneprøver)
		Scientific report (Fagrapport)

CONTENTS

1. Introduction 5

2. Borehole information 6

3. Comparison of fracture frequency and RQD from 2005 and 2006 7-21

Fracture frequency by depth 2005 7

Fracture frequency by depth 2006 8

RQD by depth 2005 9

RQD by depth 2006 10

Fracture frequency vs. RQD upper borehole 11

Fracture frequency vs. RQD middle borehole 12

Fracture frequency vs. RQD lower borehole 13

Data table to graphs 14-22

4. Borehole logs 25-222

Upper borehole no. 1 2005 25-45

Middle borehole no. 1 (inclined) 2005 49-66

Middle borehole no. 2 2005 69-90

Lower borehole no. 1 2005 93-116

Upper borehole no. 2 2006 119-142

Middle borehole no. 3 2006 145-166

Lower borehole no. 2 2006 169-192

5. Lab methods 195-222

XRD – clay mineral identification 195-196

Thin section 197-198

Thermal Conductivity 199-204

ISRM Standards 205-206

Tensile Rock Strength 207-209

Sound Velocity 210-215

Uniaxial Compressive Strength 216-219

SINTEF report on engineering geology parameters 220-222

Introduction

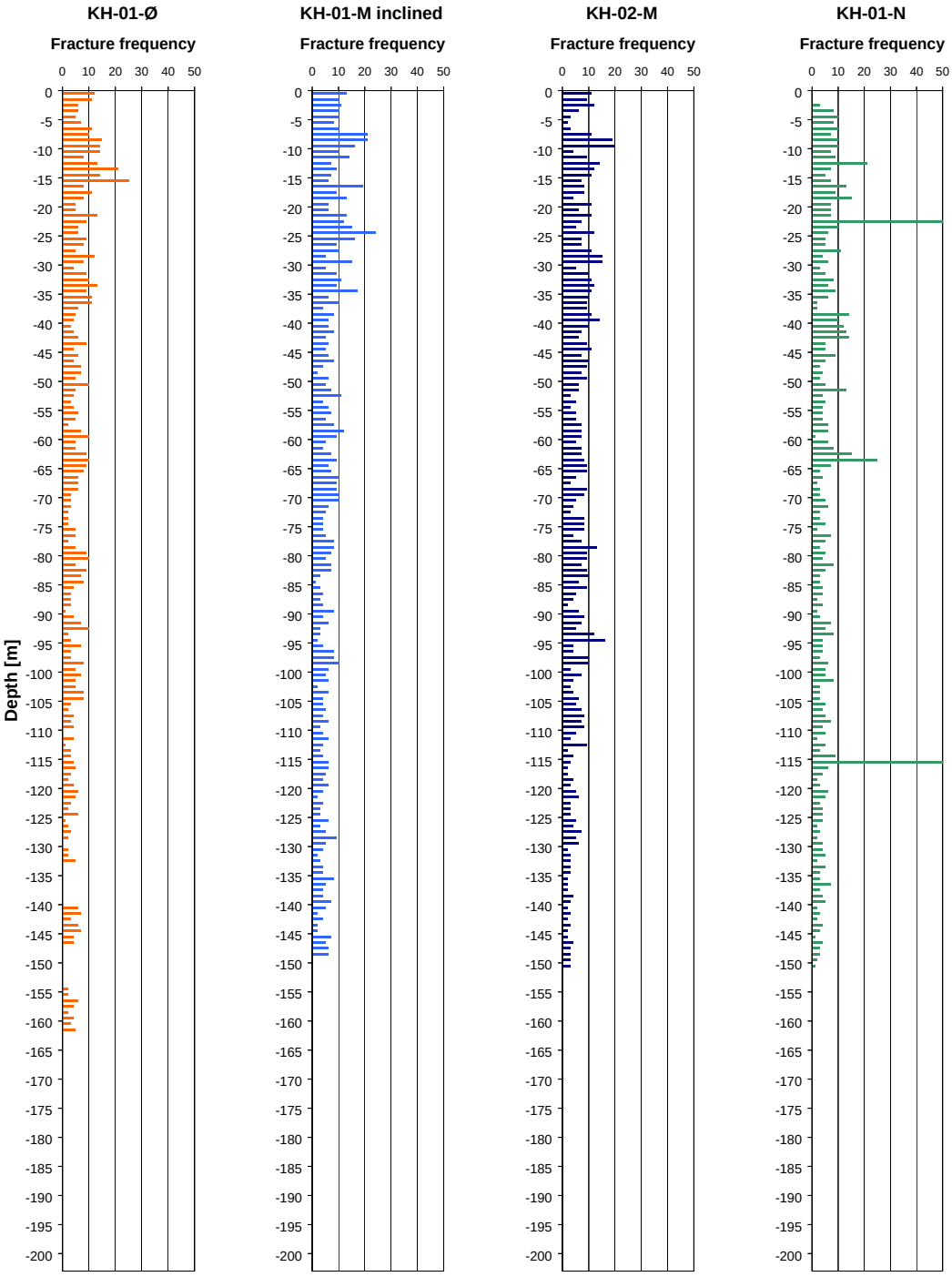
A total of seven boreholes are drilled at Åknes, Stranda municipality, Møre og Romsdal County. Three drill sites are established, Upper, Middle and Lower, where two boreholes are drill at Upper and Lower drill site while three boreholes are drilled at middle drill site, including the inclined borehole. Four boreholes were drilled in 2005, where three were vertical and one inclined, all at depths of about 150 meter. The next three boreholes were drilled in 2006, all vertical and down to about 200 meters depth.

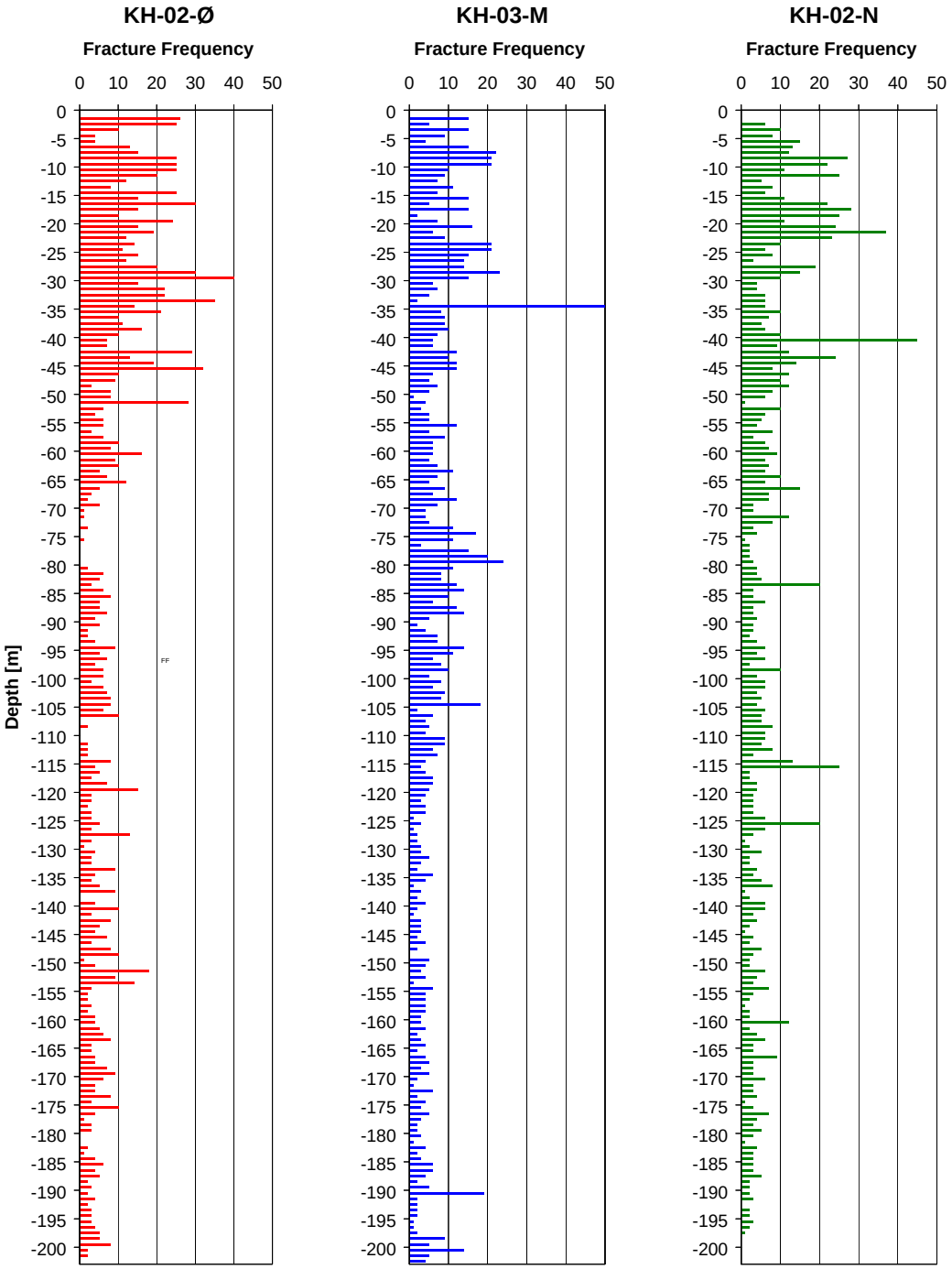
All drill cores are logged and reported here. The logging method used is meter by meter and parameters included in the logging are; depth, bedrock type, content of mafic minerals (%), occurrence of fracture zones, occurrence of crushed rock, total fracture frequency pr meter, number of fractures that are parallel to foliation pr meter, frequency of other fractures pr meter, angle between fracture and core axis, RQD, samples, type of analyses for sample, where analysis is performed, who is in charge of sample and results, remaining sample material and comments to drill core. Method description for the analysis performed on the collected samples is given.

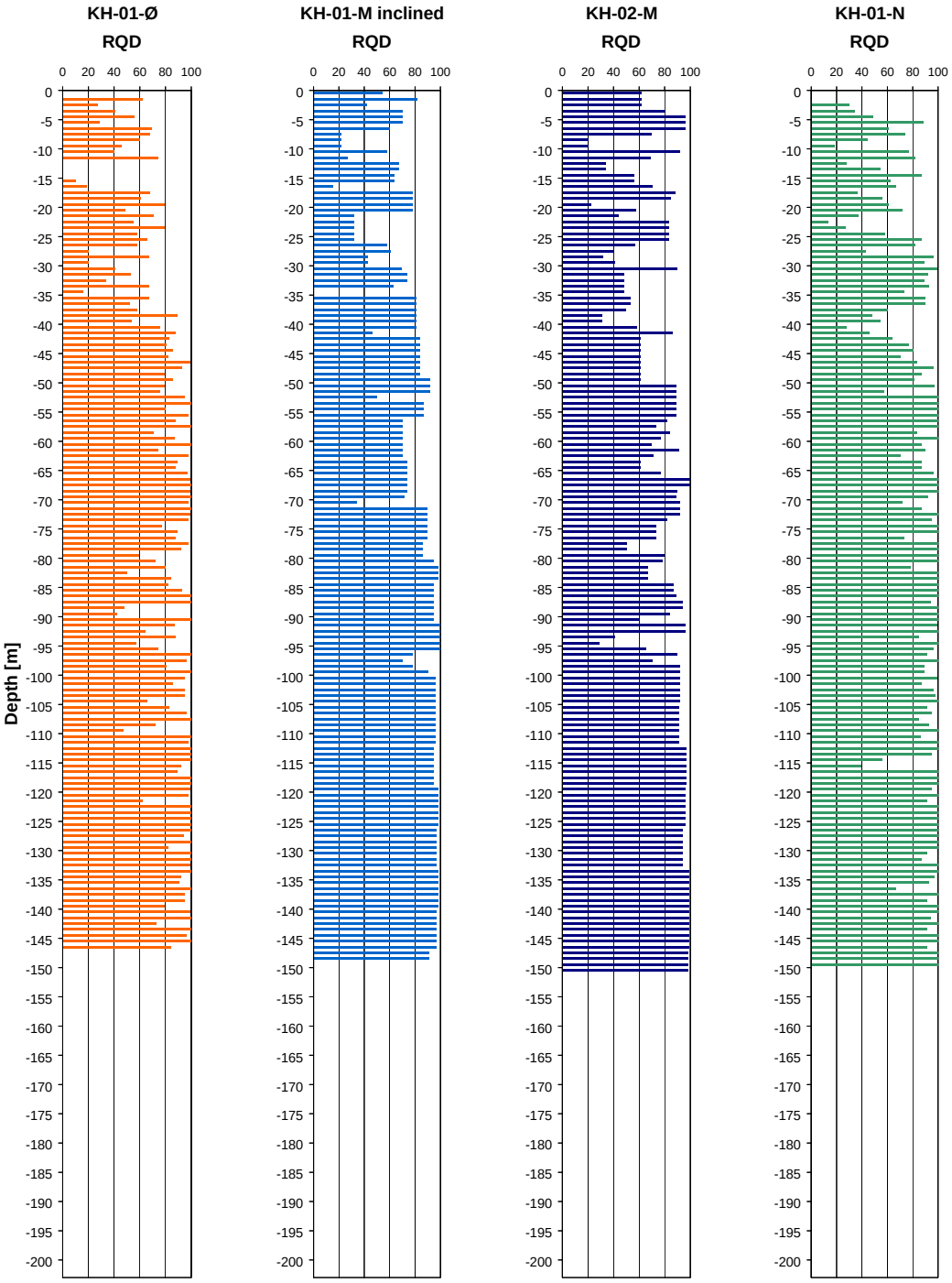
All boreholes are logged by geophysical parameters such as fluid conductivity, temperature, bedrock resistivity, seismic logging of P- and S-wave, gamma ray and water quality. Results from these loggings are reported separately. In addition several of the boreholes are continuous monitored of piezometer and temperature, as well as a DEM column in Upper and Middle borehole. These results are also reported separately.

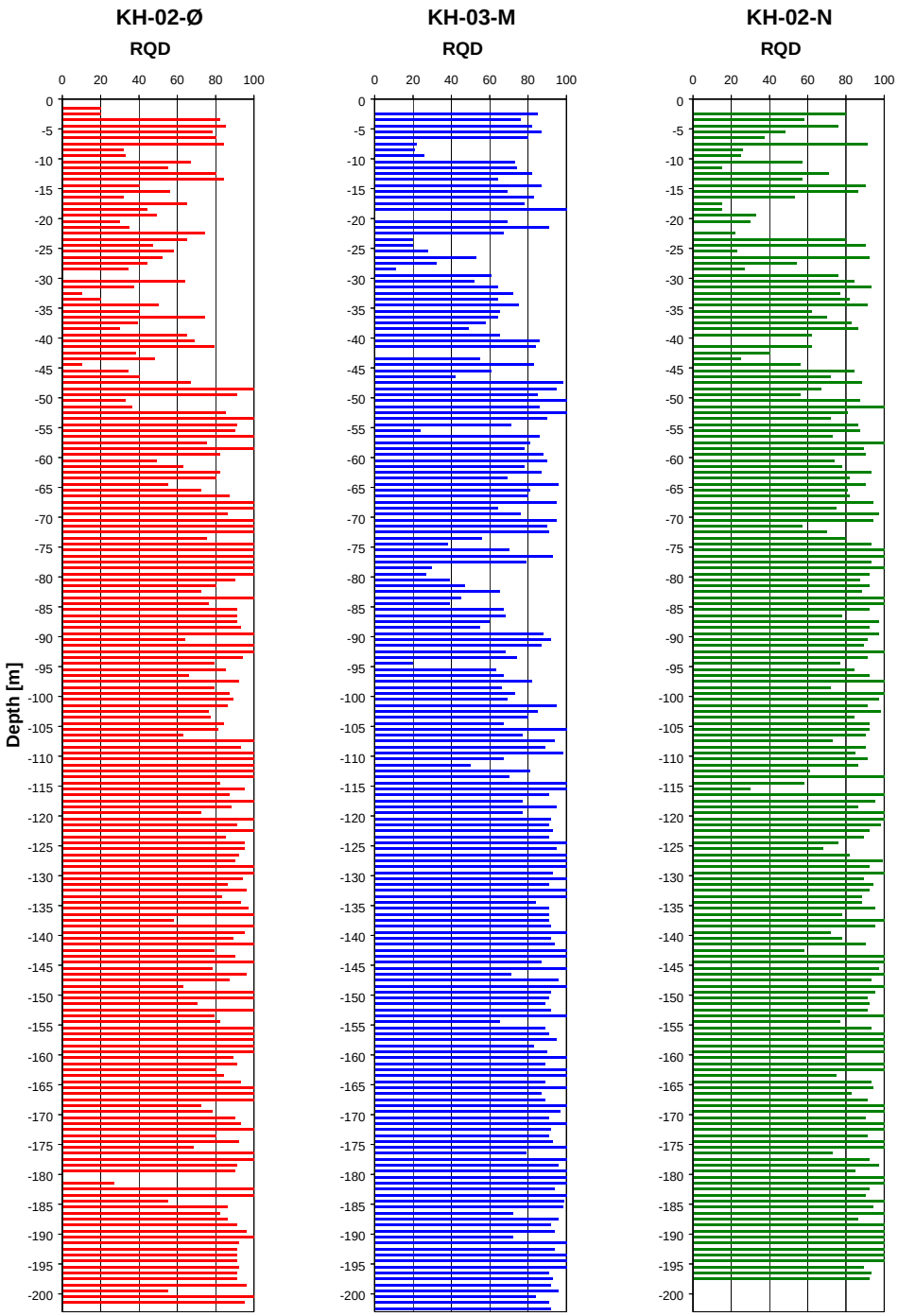
					WGS 1984, UTM zone 32 N			
Borehole	**BH**	**Drilling year**	**Boreholes**	**Location**	**UTM_E**	**UTM_N**	**Elevation (m)**	**Dip angle (degrees)**
BH C1a	KH-01-M	2005	Middle bh inclined	Midtre 1A	395619	6895736	565	60
BH C2	KH-01-Ø	2005	Upper bh 1	Øvre 1	395410	6895804	658	90
BH C3	KH-01-N	2005	Lower bh 1	Nedre 1	395839	6895312	236	90
BH C4	KH-02-Ø	2006	Upper bh 2	Øvre 2	395407	6895803	658	90
BH C6	KH-02-N	2006	Lower nh 2	Nedre 2	395836	6895313	236	90
BH C1b	KH-02-M	2005	Middle bh vertical 1	Midtre 1B	395613	6895736	565	90
BH C5	KH-03-M	2006	Middle bh vertical 2	Midtre 2	395621	6895737	565	90

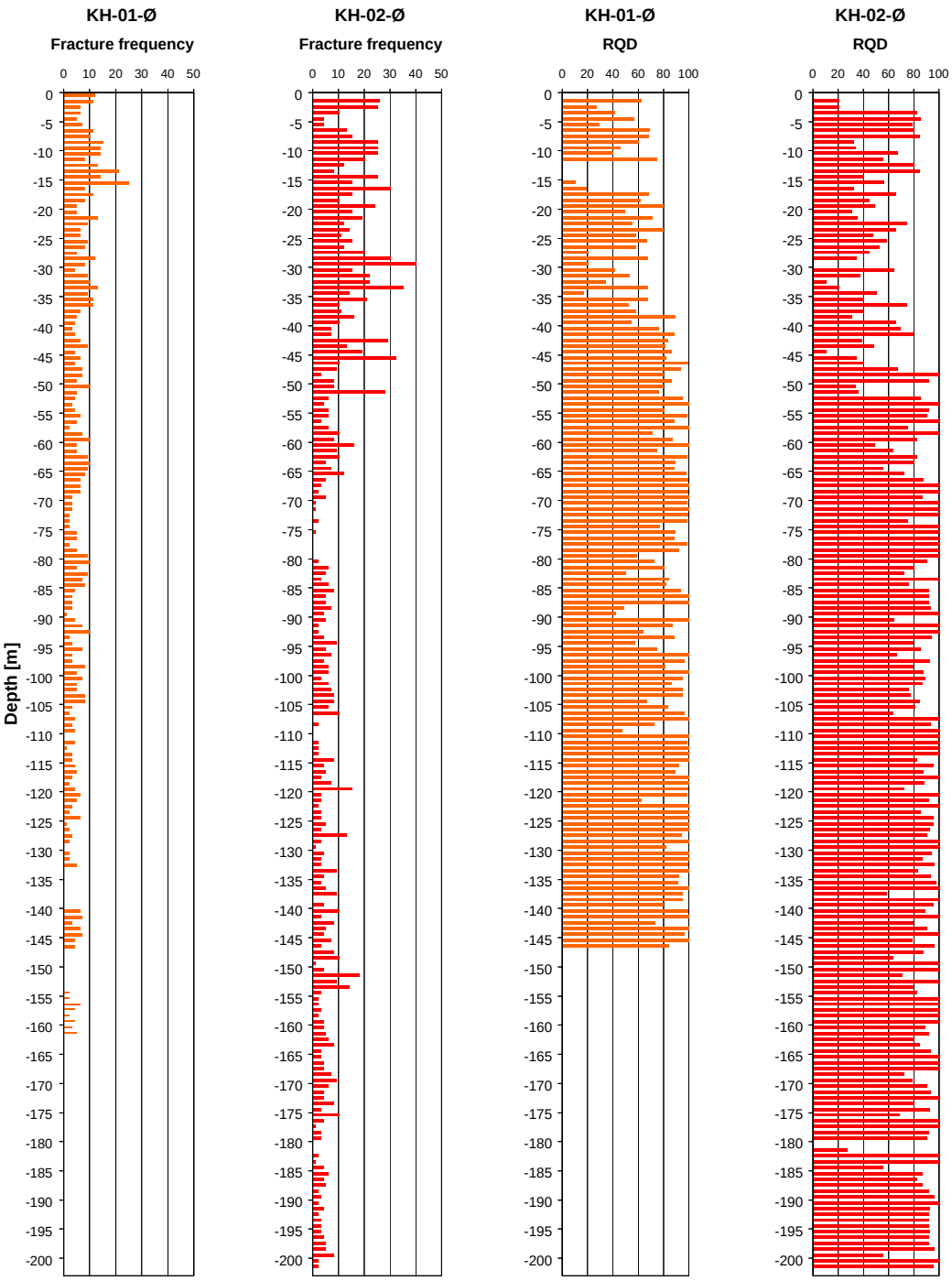
BH	**Observations**	**Location**	**Year**
KH-01-M	Water conductivity, water temperature, total gamma bedrock	Midtre borehull 1A	2005
KH-01-Ø	Water temperature, ground water table, water conductivity (NGI)	Øvre borehull 1	2005
KH-01-N	Water temperature, ground water table, water conductivity (NGI)	Nedre borehull 1	2005
KH-02-Ø	Inclinometer (movement), pore pressure, water temperature (DMS)	Øvre borehull 2	2006
KH-02-N	Inclinometer (movement), pore pressure, water temperature (DMS)	Nedre borehull 2	2006
KH-02-M	Inclinometer (movement), pore pressure, water temperature (DMS)	Midtre borehull 1B	2006
KH-03-M	Water temperature, ground water table, water conductivity (NGI)	Midtre borehull 2	2005

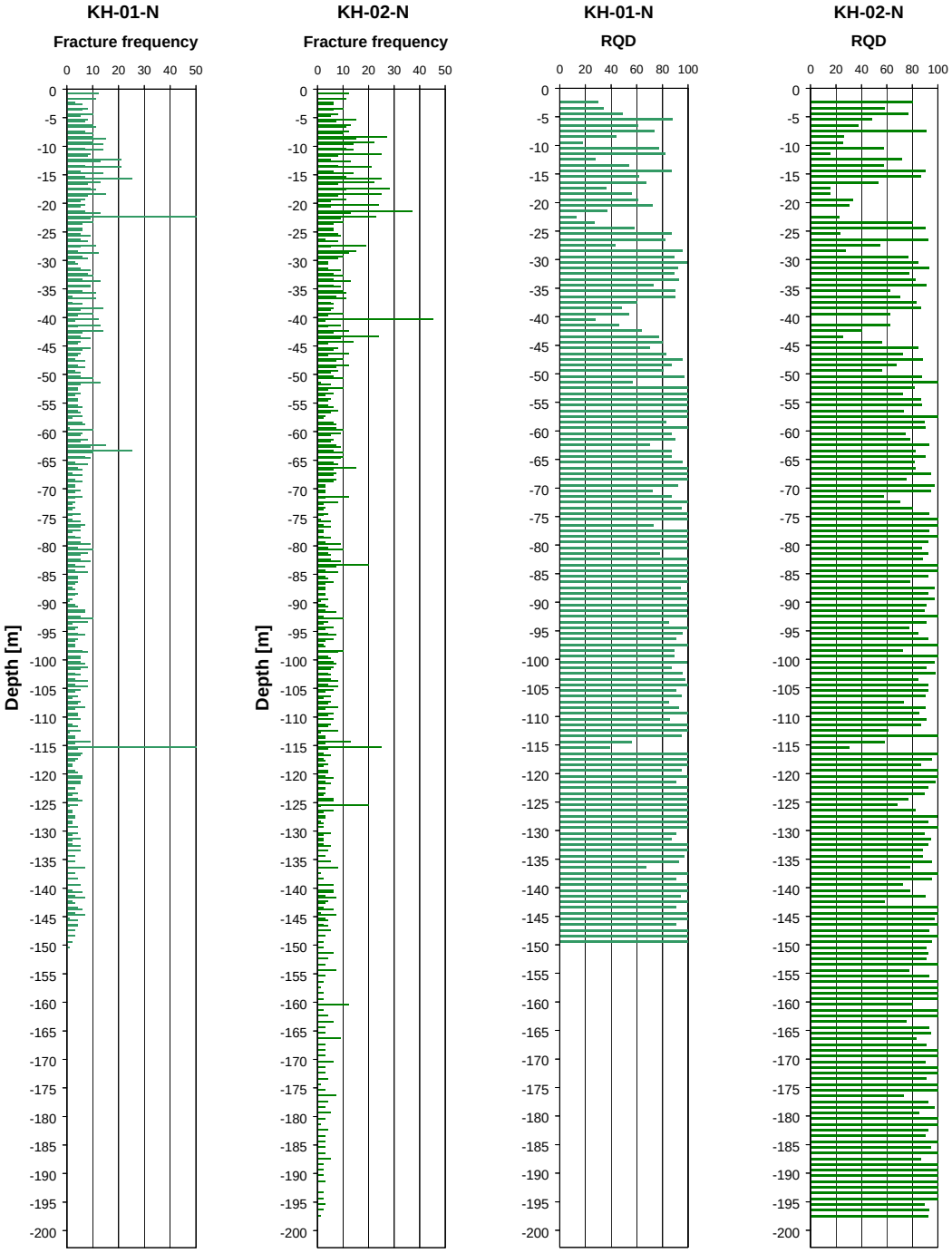

KH-01-Ø
Fracture frequency
KH-01-M inclined
Fracture frequency
KH-02-M
Fracture frequency
KH-01-N
Fracture frequency
Depth [m]

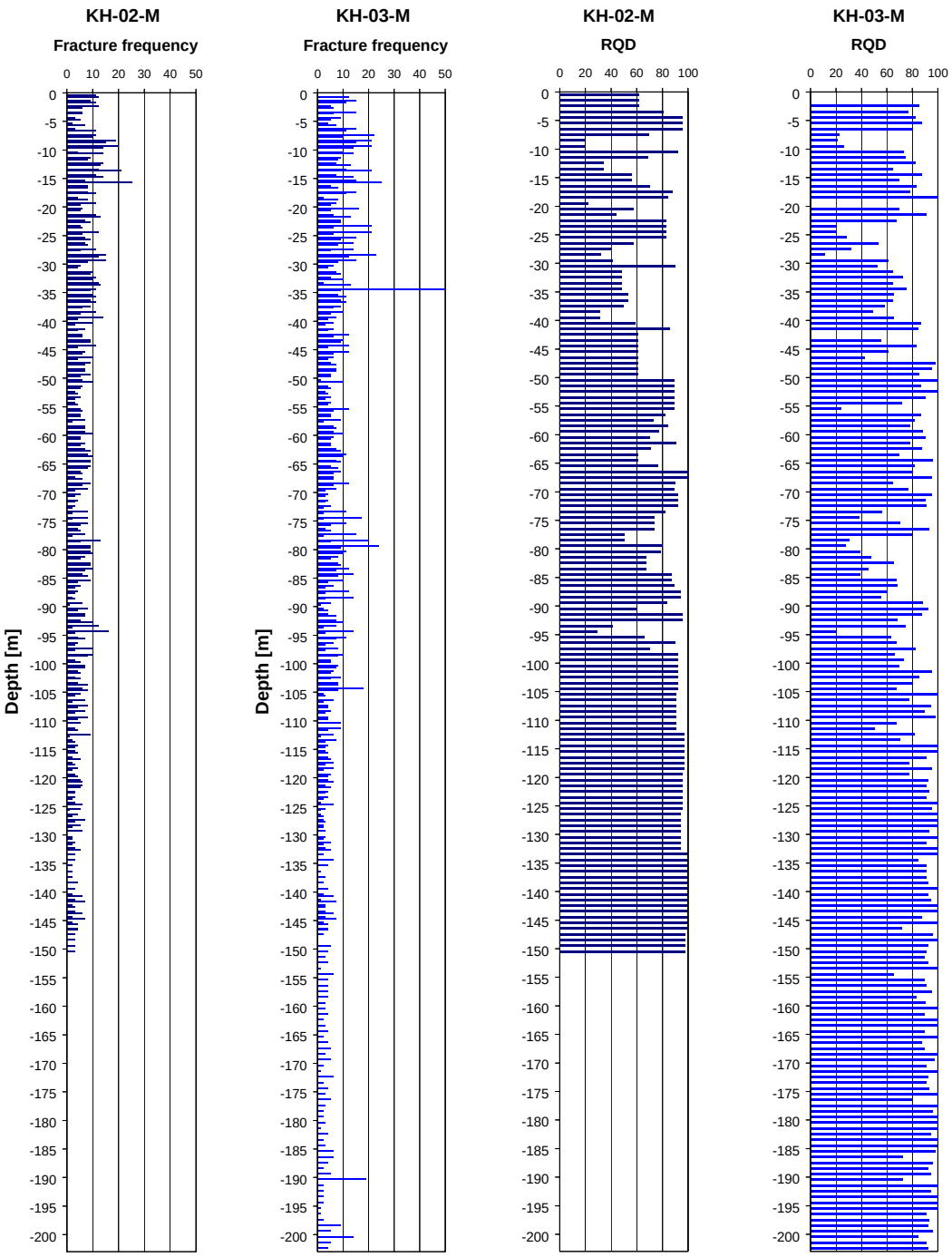

KH-02-Ø
Fracture Frequency
KH-03-M
Fracture Frequency
KH-02-N
Fracture Frequency
Depth [m]


KH-01-Ø
RQD
KH-01-M inclined
RQD
KH-02-M
RQD
KH-01-N
RQD
Depth [m]
0 20 40 60 80 100
0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110 -115 -120 -125 -130 -135 -140 -145 -150 -155 -160 -165 -170 -175 -180 -185 -190 -195 -200


KH-02-Ø
RQD
KH-03-M
RQD
KH-02-N
RQD
Depth [m]
0
20
40
60
80
100
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
-95
-100
-105
-110
-115
-120
-125
-130
-135
-140
-145
-150
-155
-160
-165
-170
-175
-180
-185
-190
-195
-200


KH-01-Ø
Fracture frequency
KH-02-Ø
Fracture frequency
KH-01-Ø
RQD
KH-02-Ø
RQD
Depth [m]


KH-01-N
Fracture frequency
KH-02-N
Fracture frequency
KH-01-N
RQD
KH-02-N
RQD
Depth [m]
Depth [m]


KH-02-M
Fracture frequency
KH-03-M
Fracture frequency
KH-02-M
RQD
KH-03-M
RQD
Depth [m]
Depth [m]

Depth	2006					
	Effective Fracture Frequency			RQD		
	KH-02-Ø	KH-03-M	KH-02-N	KH-02-Ø	KH-03-M	KH-02-N
0				0	0	
-1	26	15		20	50 (25/50)	
-2	25	5	6	20	85	80
-3	10	15	10	82	76	58
-4	4	9	8	85	82	76
-5	4	4	15	78	87	48
-6	13	15	13	80	80	37
-7	15	22	12	84	22	91
-8	25	21	27	32	21	26
-9	25	21	22	33	26	25
-10	25	10	11	67	73	57
-11	20	9	25	55	74	15
-12	12	7	5	80	82	71
-13	8	11	8	84	64	57
-14	25	7	6	40	87	90
-15	15	15	11	56	69	86
-16	30	5	22	32	83	53
-17	15	15	28	65	78	15
-18	10	2	25	44	100	15
-19	24	7	11	49		33
-20	15	16	24	30	69	30
-21	19	6	37	35	91	0
-22	12	9	23	74	67	22
-23	14	21	10	65	20	80
-24	11	21	6	47	20	90
-25	15	15	8	58	28	23
-26	12	14	3	52	53	92
-27	20	14	19	44	32	54
-28	30	23	15	34	11	27
-29	40	15	10	0	61	76
-30	15	6	4	64	52	84
-31	22	7	4	37	64	93
-32	22	5	6	10	72	77
-33	35	2	6	20	64	82
-34	14	50	6	50	75	91
-35	21	8	10	40	65	62
-36	10	9	7	74	64	70
-37	11	9	5	39	58	83
-38	16	10	6	30	49	86
-39	10	7	10	65	65	62
-40	7	6	45	69	86	0
-41	7	6	9	79	84	62
-42	29	12	12	38		40
-43	13	10	24	48	55	25
-44	19	12	14	10	83	56
-45	32	12	8	34	61	84
-46	10	6	12	40	42	72
-47	9	5	10	67	98	88
-48	3	7	12	100	95	67
-49	8	5	8	91	85	56
-50	8	1	6	33	100	87
-51	28	4	1	36	86	100

Depth	2006					
	Effective Fracture Frequency			RQD		
	KH-02-Ø	KH-03-M	KH-02-N	KH-02-Ø	KH-03-M	KH-02-N
-52	6	3	10	85	100	81
-53	4	5	6	100	90	72
-54	6	5	5	91	71	86
-55	6	12	4	90	24	87
-56	3	5	8	100	86	73
-57	6	9	3	75	81	100
-58	10	6	6	100	78	89
-59	8	6	7	82	88	90
-60	16	6	9	49	90	74
-61	9	5	6	63	78	78
-62	10	7	7	82	87	93
-63	5	11	6	80	69	82
-64	7	7	10	55	96	90
-65	12	5	6	72	81	81
-66	5	9	15	87	80	82
-67	3	6	7	100	95	94
-68	2	12	7	100	64	75
-69	5	7	3	86	76	97
-70	1	4	3	100	95	94
-71	1	4	12	100	90	57
-72	0	5	8	100	91	70
-73	2	11	3	75	56	80
-74	0	17	4	100	38	93
-75	1	11	1	100	70	100
-76	0	3	2	100	93	100
-77	0	15	2	100	79	93
-78	0	20	2	100	30	100
-79	0	24	3	100	27	92
-80	2	11	4	90	39	87
-81	6	8	4	80	47	92
-82	5	8	5	72	65	88
-83	3	12	20	100	45	100
-84	6	14	3	76	39	100
-85	8	10	3	91	67	92
-86	5	6	6	91	68	78
-87	5	12	3	91	60	97
-88	7	14	3	93	55	92
-89	4	5	4	100	88	97
-90	5	2	3	64	92	91
-91	2	4	3	100	87	89
-92	2	7	2	100	68	100
-93	4	7	4	94	74	91
-94	9	14	6	79	20	77
-95	5	11	4	85	63	84
-96	7	6	6	66	67	92
-97	4	8	2	92	82	100
-98	6	10	10	79	66	72
-99	6	5	4	87	73	100
-100	3	8	6	89	69	97
-101	6	6	6	86	95	91
-102	7	9	4	76	85	98
-103	8	8	5	77	80	84

Depth	2006					
	Effective Fracture Frequency			RQD		
	KH-02-Ø	KH-03-M	KH-02-N	KH-02-Ø	KH-03-M	KH-02-N
-104	8	18	4	84	67	92
-105	6	2	6	81	100	92
-106	10	6	5	63	77	90
-107	0	4	5	100	94	73
-108	2	5	8	93	89	90
-109	0	4	6	100	98	85
-110	0	9	6	100	67	91
-111	2	9	5	100	50	86
-112	2	6	8	100	81	61
-113	2	7	3	100	70	100
-114	8	4	13	82	100	58
-115	4	3	25	95	100	30
-116	5	4	2	87	91	100
-117	3	6	2	100	77	95
-118	7	6	4	88	95	86
-119	15	5	4	72	77	100
-120	3	4	3	100	92	100
-121	3	3	3	91	91	98
-122	2	4	3	100	93	92
-123	3	4	3	85	91	89
-124	3	1	6	95	100	76
-125	5	3	20	95	95	68
-126	3	1	6	92	100	82
-127	13	2	3	90	100	99
-128	3	2	1	100	100	92
-129	1	3	2	100	93	100
-130	4	3	5	94	100	89
-131	3	5	2	86	91	94
-132	3	3	2	96	100	92
-133	9	2	4	83	100	88
-134	4	6	3	93	84	88
-135	3	4	5	97	91	95
-136	5	1	8	100	91	78
-137	9	3	1	58	91	100
-138	0	2	2	100	92	95
-139	4	4	6	95	100	72
-140	10	2	6	89	92	78
-141	3	1	3	100	94	90
-142	8	3	4	79	100	58
-143	5	3	2	90	100	100
-144	4	3	1	100	87	100
-145	7	2	3	78	100	97
-146	3	4	2	96	71	100
-147	8	2	5	87	96	93
-148	10	0	3	63	100	100
-149	1	5	2	100	92	95
-150	4	4	2	100	91	91
-151	18	3	6	70	89	92
-152	9	4	4	100	92	91
-153	14	1	3	79	100	100
-154	3	6	7	82	65	77
-155	2	4	3	100	89	93

Depth	2006					
	Effective Fracture Frequency			RQD		
	KH-02-Ø	KH-03-M	KH-02-N	KH-02-Ø	KH-03-M	KH-02-N
-156	2	4	2	100	91	100
-157	3	4	1	100	95	100
-158	2	4	2	100	83	100
-159	4	3	2	100	90	100
-160	4	3	12	89	100	80
-161	5	4	2	91	89	100
-162	6	2	4	80	100	100
-163	8	3	6	84	100	75
-164	3	4	3	93	89	93
-165	3	2	3	100	100	94
-166	4	4	9	100	87	83
-167	4	5	3	100	89	91
-168	7	3	3	72	100	100
-169	9	5	3	78	97	100
-170	6	2	6	90	91	90
-171	4	1	3	93	100	100
-172	4	6	3	100	92	100
-173	8	2	4	80	91	91
-174	3	4	1	92	93	100
-175	10	3	3	68	100	100
-176	4	5	7	100	79	73
-177	1	3	4	100	100	92
-178	3	2	3	91	96	97
-179	3	2	5	90	100	85
-180	0	3	3	0	100	100
-181	0	1	1	27	100	100
-182	2	4	4	100	94	92
-183	1	2	3	100	100	90
-184	4	3	3	55	99	100
-185	6	6	3	86	98	94
-186	4	6	3	82	72	100
-187	5	4	5	86	96	86
-188	2	2	2	91	92	100
-189	3	5	2	96	94	100
-190	2	19	2	100	72	100
-191	4	2	3	92	100	100
-192	2	2	0	91	94	100
-193	3	2	2	91	100	100
-194	3	2	2	91	100	100
-195	3	1	3	92	100	89
-196	4	1	2	91	91	93
-197	5	2	1	91	93	92
-198	5	9		96	92	
-199	8	5		55	96	
-200	2	14		100	84	
-201	2	5		95	91	
-202		4			92	

Depth	2005							
	Effective Fracture frequency				RQD			
	KH-01-Ø	KH-01-M	KH-02-M	KH-01-N	KH-01-Ø	KH-01-M	KH-02-M	KH-01-N
0	12	13	11		0	54	62	
-1	11	10	9		62	82	62	
-2	6	11	12	3	27	42,1	62	30
-3	6	10	6	8	41	70	80,7	34
-4	5	10	3	10	56	70	96	49
-5	7	8	2	8	29	70	96	88
-6	11	10	3	10	69	60,4	96	61
-7	10	21	11	7	68	22	69,4	74
-8	15	21	19	10	60	22	20	44
-9	14	16	20	10	46	22	20	18
-10	14	10	4	7	40	58	92	77
-11	8	14	9	9	74	26,9	68,8	82
-12	13	7	14	21	0	67	34	28
-13	21	9	12	7	0	67	34	54
-14	14	7	11	5	0	64	56	87
-15	25	6	7	7	10	64	56	62
-16	8	19	8	13	19	15,6	70,4	67
-17	11	9	8	9	68	78	88	36
-18	8	13	4	15	61	78	84,5	56
-19	5	6	11	7	79	78	22,4	61
-20	5	6	6	7	49	78	57,4	72
-21	13	13	11	7	71	32	43,7	37
-22	9	12	7	50	55	32	83	13
-23	6	15	5	10	79	32	83	27
-24	6	24	12	6	58	32	83	58
-25	9	16	7	5	66	32	83	87
-26	8	9	7	5	58	58,1	57,2	82
-27	5	10	11	11	20	61	40	43
-28	12	5	15	4	67	43	32	96
-29	8	15	15	6	20	43	41	89
-30	4	5	5	3	41	69,4	89,8	99
-31	9	9	10	5	53	74	48	92
-32	10	11	11	8	34	74	48	89
-33	13	9	12	6	67	62,9	48	93
-34	9	17	11	9	16	0	48	73
-35	11	6	10	6	67	81	53	90
-36	11	10	9	2	52	81	53	90
-37	6	4	9	2	58	81	49,7	60
-38	5	8	11	14	89	81	31	48
-39	4	6	14	10	54	81	31	54
-40	3	6	10	12	76	81	58,5	28
-41	4	8	7	13	88	46,2	86	46
-42	6	5	6	14	83	84	61	64
-43	9	6	9	5	81	84	61	77
-44	4	5	11	5	86	84	61	80
-45	6	6	7	9	82	84	61	70
-46	4	8	10	5	99	84	61	83
-47	7	4	9	3	93	84	61	96
-48	7	2	7	4	79	84	61	87
-49	5	6	9	3	86	92	61,1	81
-50	10	5	6	5	79	92	89	97
-51	5	7	6	13	76	92	89	57

Depth	2005							
	Effective Fracture frequency				RQD			
	KH-01-Ø	KH-01-M	KH-02-M	KH-01-N	KH-01-Ø	KH-01-M	KH-02-M	KH-01-N
-52	4	11	3	4	95	50,1	89	100
-53	3	4	5	5	100	87	89	100
-54	4	6	3	4	80	87	89	100
-55	6	7	5	4	98	87	89	100
-56	5	5	5	4	88	70	82	100
-57	2	8	7	6	100	70	73	100
-58	7	12	7	6	71	70	84	83
-59	10	9	7	1	87	70	77	100
-60	5	5	5	6	100	70	70	87
-61	5	4	7	8	74	70	91	90
-62	9	7	7	15	98	70	71	70
-63	10	9	8	25	89	73,4	61	87
-64	9	6	9	7	88	74	61	87
-65	8	7	9	3	97	74	76,6	96
-66	6	10	5	4	99	74	100	100
-67	6	9	3	2	100	74	100	100
-68	6	9	9	3	99	74	89,6	100
-69	3	10	8	3	100	71,7	89	92
-70	3	10	5	5	98	34	92	72
-71	3	6	4	6	100	90	92	87
-72	2	5	3	3	99	90	92	100
-73	2	4	8	3	98	90	81,8	95
-74	2	4	8	5	77	90	73,5	100
-75	5	4	8	2	89	90	73,5	100
-76	5	5	4	7	88	90	73,5	73
-77	2	8	7	5	98	86	50	100
-78	5	8	13	3	92	86	50	100
-79	9	7	9	5	59	86	80	100
-80	10	5	9	4	72	94,4	78,6	100
-81	5	7	7	8	80	98	67	78
-82	9	7	9	5	50	98	67	100
-83	7	3	10	3	84	98	67	100
-84	8	1	6	3	82	95	87	100
-85	4	3	9	4	93	95	87	100
-86	3	4	5	4	100	95	89,1	100
-87	3	3	4	2	100	95	94	94
-88	3	4	2	4	48	95	94	100
-89	1	8	6	2	42	95	83,8	100
-90	4	4	8	3	100	95	60	100
-91	7	6	7	7	87	100	96	99
-92	10	3	5	5	64	100	96	100
-93	2	3	12	8	88	100	41,1	85
-94	3	2	16	4	57	100	29	100
-95	7	4	4	4	74	100	65,6	96
-96	3	8	4	4	100	78,4	90	91
-97	3	8	10	3	96	70	70,4	100
-98	8	10	10	6	81	78	92	89
-99	5	6	3	5	100	90,6	92	89
-100	7	5	7	5	95	96	92	99
-101	5	6	4	8	86	96	92	87
-102	5	2	3	3	95	96	92	96
-103	8	6	4	3	95	96	92	98

Depth	2005							
	Effective Fracture Frequency				RQD			
	KH-01-Ø	KH-01-M	KH-02-M	KH-01-N	KH-01-Ø	KH-01-M	KH-02-M	KH-01-N
-104	8	4	6	3	66	96	92	100
-105	3	4	5	5	83	96	91	91
-106	2	5	7	4	96	96	91	95
-107	4	4	8	5	100	96	91	85
-108	3	6	7	7	72	96	91	93
-109	4	3	8	4	47	96	91	100
-110	0	4	5	5	100	96	91	86
-111	4	6	3	2	98	96	91	100
-112	1	4	9	5	100	95	97	100
-113	3	3	2	3	100	95	97	95
-114	3	4	4	9	100	95	97	56
-115	4	6	3	50	92	95	97	39
-116	5	6	2	6	89	95	97	100
-117	3	5	2	4	100	95	97	100
-118	2	4	4	2	100	95	97	100
-119	4	6	3	3	99	98	96	95
-120	6	4	5	6	98	98	96	100
-121	5	2	6	5	62	98	96	91
-122	3	4	3	3	100	98	96	100
-123	2	3	3	4	100	98	96	100
-124	6	3	3	4	100	98	96	100
-125	1	6	5	4	100	98	96	100
-126	2	3	4	2	100	97	94	100
-127	3	5	7	3	94	97	94	100
-128	2	9	5	2	100	97	94	100
-129	0	5	6	4	82	97	94	100
-130	2	4	2	4	100	97	94	91
-131	2	2	3	5	100	97	94	87
-132	5	3	3	2	99	97	94	100
-133		4	3	5	100	98	99	100
-134		4	3	3	92	98	99	97
-135		8	2	3	91	98	99	93
-136		5	2	7	100	98	99	67
-137		4	2	3	95	98	99	100
-138		4	4	4	95	98	99	91
-139		7	3	5	79	98	99	100
-140	6	5	2	2	99	97	99	100
-141	7	2	3	3	100	97	99	94
-142	3	4	2	2	73	97	99	100
-143	6	2	3	4	100	97	99	91
-144	7	2	2	3	96	97	99	100
-145	4	7	2	1	100	97	99	100
-146	4	5	4	4	84	97	99	91
-147		6	3	3		91	98	100
-148		6	3	3		91	98	100
-149			3	2			98	100
-150			3	1			98	
-151								
-152								
-153								
-154	2							
-155	2							

Depth	2005							
	Effective Fracture Frequency				RQD			
	KH-01-Ø	KH-01-M	KH-02-M	KH-01-N	KH-01-Ø	KH-01-M	KH-02-M	KH-01-N
-156	6							
-157	4							
-158	2							
-159	4							
-160	3							
-161	5							

BG = Biotittic gneiss
GG = granittic gneiss
DG = diorittic gneiss
PEG = pegmatite

*The fracture frequency is neither truncated or censored.
Fractures that is obviously made by the drilling process is not included.
This will (probably) give a higher fracture frequency than the background fractureing with at least 20 %.
** The fracture frequency is based on the in-situ fractures (estimations by Guro Grøneng)

The bedrock is very heterogen and drawing the boundary between the different types is difficult.
The content of mafic minerals is given by ca %, also indicating the changes in the bedrock.
Where several bedrock types are indicated, there is a frequent change in bedrock, indicating it beenig even more heterogen.

KH-01-Ø 2005 - Upper borehole no 1 (Drillcore c2)

Coordinates N6895802 E395469 Height above sea level ca: 640 m a.sl.

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed rock [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
0	GG	50-60	Core loss	12	12	21	9
-1	GG / BG	60 / 70		9	11	13	9
-2	GG	15		3	6	3	4
-3	GG	15	Core loss 25 cm	5	6	4	2
-4	GG	20	Core loss / crushed zone 45 cm	8	5	8	3
-5	GG	15			7	9	4
-6	GG	20			11	9	8
-7	GG / BG	20 / 70			10	7	10
-8	GG / BG	60-70		4	15	9	11
-9	GG / BG	60			14	12	10
-10	BG (GG)	60-70		3	14	10	9
-11	BG (GG)	60		10	8	6	5

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed rock [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-12	DG	40	Core loss / crushed zone most of the meter	40	13	25	13
-13	DG	40	Crushed zone ca 40 cm	58	21	23	18
-14	DG / BG	50 / 60	Crushed zone ca 40 cm	39	14	14	
-15	DG	50	Crushed zone for most of the meter	6	25	25	
-16	DG	60	Core loss and crushed zone ca 30 cm	5	8	8	
-17	DG / BG	60 / 75			11	11	10
-18	DG	50-60	Crushed zone ca 20 cm	19	8	8	
-19	DG / BG	50 / 70			5	5	
-20	BG / DG	60 / 40		4	5	11	5
-21	DG	40-50			13	11	6
-22	DG	50	Crushed zone	17	9	9	5
-23	DG	50-60			6	6	5
-24	DG	50-60			6	10	6
-25	DG	50			9	9	3
-26	DG	50		9	8	11	6
-27	DG	30	Crushed zone most of the meter	48	5	10	5
-28	DG	30	Small zones of crushed rock	17	12	5	9
-29	DG	30	Crushed zone and core loss	12	8	8	
-30	DG	30			4	9	4
-31	DG	30	small zone of crushed rock		9	11	4
-32	DG	30		9	10	12	6
-33	DG	30-40			13	10	9
-34	DG	30-40			9	16	5

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed rock [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-35	DG	40			11	9	8
-36	DG	40		3	11	9	7
-37	DG	40	Voids		6	10	6
-38	GG	25			5	6	5
-39	GG	15			4	3	4
-40	GG	05.okt			3	6	3
-41	GG	30-40			4	4	4
-42	GG / DG	40		2	6	3	4
-43	DG	40		6	9	7	9
-44	DG	40	possible crushed zone ca 8 cm thick		4	4	4
-45	GG	30			6	5	6
-46	GG	20-30			4	1	4
-47	GG / DG	20 / 50	Possible crushed zone ca 3 cm thick	4	7	3	5
-48	DG	50	Possible zone of crushed rock at 48,87 m -Max 10 cm wide	13	7	7	7
-49	BG / DG	50 / 30		5	5	5	5
-50	DG	30		1	10	7	7
-51	DG	30-40		8	5	5	3
-52	DG	30			4	2	4
-53	DG	30			3	1	3
-54	DG	30			4	4	4
-55	DG	30-40			6	3	5
-56	DG	10			5	4	5

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed rock [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-57	DG	40			2	2	2
-58	DG	20		5	7	7	7
-59	GG	50	Voids		10	2	10
-60	GG	50			5	0	5
-61	GG	50		4	5	3	5
-62	GG	40			9	2	9
-63	GG	55		3	10	4	10
-64	GG	55			9	7	9
-65	GG	50			8	2	8
-66	BG / GG	60 / 40			6	1	6
-67	GG	50			6	0	6
-68	GG	50	Voids		6	2	6
-69	GG	30-40	Voids		3	0	3
-70	GG	25			3	3	3
-71	GG	10			3	0	3
-72	GG	30			2	2	2
-73	GG (BG)	50			2	3	2
-74	GG	50-60			2	4	2
-75	GG	50-60	Voids		5	4	5
-76	GG	40			5	4	5
-77	GG	30			2	2	2
-78	GG	30-40			5	4	5
-79	GG	20-30			9	10	9
-80	GG	30-40			10	7	10
-81	GG	40			5	8	5

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed rock [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-82	GG	40			9	12	9
-83	GG	30			7	5	7
-84	GG	35		5	8	6	8
-85	GG	25			4	4	4
-86	GG	30	Voids		3	4	3
-87	GG	15			3	7	3
-88	GG	20			3	8	3
-89	GG	20			1	7	1
-90	GG	25			4	4	4
-91	GG	20			7	7	
-92	GG	25		4	10	14	
-93	GG	40			2	4	
-94	GG	45			3	4	
-95	GG	40		4	7	7	7
-96	GG	30			3	1	3
-97	GG	35	Voids		3	3	
-98	GG	15			8	6	8
-99	GG	20			5	4	5
-100	GG	20			7	5	7
-101	GG	25			5	4	5
-102	GG	50	Voids		5	4	5
-103	GG	40-50	Voids		8	6	8
-104	GG	30-40	Voids		8	8	8
-105	DG	50			3	4	3
-106	DG	40		1	2	3	2
-107	DG	40			4	4	4
-108	BG	60			3	3	3
-109	GG	15			4	5	2

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed rock [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-110	GG	10			0	0	
-111	GG	15			4	4	4
-112	GG	15			1	0	1
-113	GG	15			3	1	3
-114	GG	15			3	2	3
-115	GG	30			4	4	4
-116	GG	40 / 10			5	4	5
-117	GG	15			3	2	3
-118	GG	20			2	1	2
-119	GG	20		1	4	3	4
-120	GG	20			6	3	6
-121	GG	30		1	5	8	5
-122	GG	45			3	1	3
-123	GG	40			2	2	2
-124	GG	20-30	Fault rock		6	1	6
-125	GG	20 / 60			1	0	1
-126	GG	40-50			2	2	2
-127	GG	40			3	2	3
-128	GG	25			2	2	2
-129	GG	30			0	1	
-130	GG	30			2	1	2
-131	GG	35			2	1	2
-132	GG / BG	60			5	4	5
-133	BG	50-60				1	
-134	BG	65				2	
-135	BG	50				3	
-136	BG	50				5	
-137	BG	50-60				4	

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed rock [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-138	BG	65				3	
-139	BG	65	Zone with partially crushed rock	21		5	
-140	BG	30-40			6	4	6
-141	BG	40	Voids		7	4	7
-142	BG	60			3	2	3
-143	BG	60			6	4	6
-144	BG	50-60			7	3	7
-145	BG	40-50			4	0	4
-146	BG	30-40			4	2	4
-147	BG	50					
-148	BG	50-60					
-149	BG	50-60					
-150	BG	60					
-151	BG	50-60					
-152	BG	60	Fault rock				
-153	BG	50					
-154	BG	40-50			2		2
-155	BG	40			2		2
-156	BG	40			6		6
-157	BG	40-50			4		4
-158	BG	50			2		2
-159	BG	40			4		4
-160	BG	40			3		3
-161	BG	50-60	Fault rock		5		5
-162	BG	50-60			**End at 162,26 meter**		

KH-01-Ø 2005 - Upper borehole no 1 (Drillcore c2)

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample	Remaining sample material
0	3		0					
-1	2		62					
-2	2		27					
-3	4		41					
-4	2		56					
-5	3		29					
-6	3		69					
-7			68					
-8	4		60					
-9	4		46					
-10	5		40					
-11	3		74					

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample	Remaining sample material
-12			0					
-13	3		0					
-14			0					
-15			10					
-16			19					
-17	1		68					
-18			61					
-19			79					
-20			49					
-21	7		71					
-22	4		55					
-23	1		79					
-24			58					
-25	6		66					
-26	2		58					
-27			20					
-28	3		67					
-29			20					
-30			41	Sample 30,2-31 m	Brazilian test + Uniaxial stress test	SINTEF	Vidar Kveldsvik (NGI)	Destructed?
-31	3		53	Sample 31,05-31,55 m	Brazilian test + Uniaxial stress test	SINTEF	Vidar Kveldsvik (NGI)	Destructed?
-32	4		34					
-33	4		67					
-34	4		16	Clay in fracture - sample 024909 at 34,35-34,5 m	XRD	NGU	Guri Venvik Ganerød (NGU)	minimal

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample	Remaining sample material
-35	3		67					
-36	4		52					
-37			58					
-38			89					
-39			54					
-40			76	Sample 40,3-41 m	Brazilian test + Uniaxial stress test	SINTEF	Vidar Kveldsvik (NGI)	Destructed?
-41			88					
-42	2		83					
-43			81	Sample 024908 at 43,5-43,6 m	Heat conductivity and thin section	NGU	Guri Venvik Ganerød (NGU)	Yes
-44			86					
-45			82					
-46			99					
-47	2		93					
-48			79					
-49			86					
-50	3		79					
-51	2		76					
-52			95					
-53			100					
-54			80					
-55	1		98					
-56			88	Tilt test at 56,25-56,5 m. Sample 24925 at 56,7-56,93 m	Tilt test / Heat conductivity	NTNU / NGU	Nicole Ragvin (NTNU) / Guri Venvik Ganerød (NGU)	Yes

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample	Remaining sample material
-57			100					
-58			71	Sample at 58,7-58,9 m	Brazilian test + Uniaxial stress test	SINTEF	Vidar Kveldsvik (NGI)	Destructed?
-59			87					
-60			100	Sample at 60,05-60,8 m	Brazilian test + Uniaxial stress test	SINTEF	Vidar Kveldsvik (NGI)	Destructed?
-61			74					
-62			98					
-63			89					
-64			88					
-65			97					
-66			99	Sample at 66-66,3 m	Brazilian test + Uniaxial stress test	SINTEF	Vidar Kveldsvik (NGI)	Destructed?
-67			100					
-68			99					
-69			100	Sample at 69,45-70 m	Brazilian test + Uniaxial stress test	SINTEF	Vidar Kveldsvik (NGI)	Destructed?
-70			98					
-71			100					
-72			99					
-73			98					
-74			77					
-75			89					
-76			88					
-77			98					
-78			92					
-79			59					
-80			72					
-81			80					

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample	Remaining sample material
-82			50					
-83			84					
-84			82					
-85			93					
-86			100					
-87			100					
-88			48	Sample 024907 at 88,2-88,35 m	Heat conductivity and thin section	NGU	Guri Venvik Ganerød (NGU)	Yes
-89			42					
-90			100					
-91	7		87					
-92	10		64					
-93	2		88					
-94	3		57					
-95			74					
-96			100					
-97			96					
-98			81					
-99			100					
-100			95					
-101			86					
-102			95					
-103			95					
-104			66					
-105			83	Sample 24924 at 105,35-105,53 m	Heat conductivity	NGU	Guri Venvik Ganerød (NGU)	Yes
-106			96					
-107			100					
-108			72					
-109	2		47					

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample	Remaining sample material
-110			100	Sample 24923 at 110,2-110,35 m	Heat conductivity	NGU	Guri Venvik Ganerød (NGU)	Yes
-111			98	Tilt test at 111,05-111,4 m	Tilt test	NTNU	Nicole Ragvin (NTNU)	Yes
-112			100					
-113			100					
-114			100					
-115			92					
-116			89					
-117			100					
-118			100					
-119			99					
-120			98					
-121			62					
-122			100					
-123			100					
-124			100					
-125			100					
-126			100					
-127			94					
-128			100					
-129			82					
-130			100					
-131			100					
-132			99					
-133			100					
-134			92	Tilt testing at 134,05-134,4 m	Tilt test	NTNU	Nicole Ragvin (NTNU)	Yes
-135			91					
-136			100	Sample 24922 at 136,15-136,35 m	Heat conductivity	NGU	Guri Venvik Ganerød (NGU)	Yes
-137			95					

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample	Remaining sample material
-138			95					
-139			79					
-140			99					
-141			100					
-142			73					
-143			100	Sample 024906 at 143,4-143,51 m	Heat conductivity and thin section	NGU	Guri Venvik Ganerød (NGU)	Yes
-144			96					
-145			100					
-146			84					
-147								
-148								
-149								
-150								
-151								
-152								
-153								
-154								
-155								
-156								
-157								
-158								
-159								
-160								
-161				Sample 024905 at 161,85-161,9 m	Thin section	NGU	Guri Venvik Ganerød (NGU)	Yes
-162								

KH-01-Ø 2005 - Upper borehole no 1 (Drillcore c2)

Depth (m)	Comments
0	Core loss 0-0,3 m
-1	
-2	
-3	Core loss from 3,75-4 m
-4	Core loss / crushed zone 4-4,45 m
-5	
-6	
-7	
-8	
-9	Epidote vain ca 2 cm - 9,4 m
-10	
-11	

Depth (m)	Comments
-12	Core loss 12-12,25 m crushed zone in most of the meter
-13	Crushed zone 13-13,3 mand 13,8-13,9 m
-14	Crushed zone 14,2-14,3 m and 14,65-14,9 m
-15	crushed zone 15-15,35 m and 15,6-15,75 m
-16	Core loss and crushed zone 16,2-16,5 m
-17	
-18	Crushed zone 18,7-18,85 m
-19	
-20	
-21	
-22	
-23	
-24	
-25	
-26	
-27	crushed zone 27-27,5 m and 27,8-27,9 m possible breccia
-28	crushed zone at 28,5 m and 28,75 m max 5 cm thick
-29	Crushed zone 29-29,1 m core loss 29,1-29,55 m
-30	
-31	Small zones of crushed rock at 31,70 - max 5 cm wide
-32	
-33	
-34	Clay in fracture - smaple 024909 for XRD at 34,35-34,5 m Pictures 7234-7238

Depth (m)	Comments
-35	
-36	
-37	Voids at several occations following the foliation. Pictures of voids at37,55 m 7232-7233
-38	
-39	
-40	Sample to NGI / SINTEF by Vidar Kveldsvik40,3-41 m
-41	
-42	
-43	Sample for heat conductivity and bedrock 024908 at 43,5-43,6 m pictures 7230-7231
-44	Possible crushed zone at 44,5 m - max 8cm thick
-45	
-46	
-47	Possible 3 cm thick zone of crushed rock
-48	Possible zone of crushed rock at 48,87 m -Max 10 cm wide
-49	Fractures with clay
-50	
-51	
-52	
-53	
-54	
-55	
-56	Tilt test at 56,25-56,5 m

Depth (m)	Comments
-57	
-58	Fractures with clay. Sample NGI / SINTEF by Vidar Kveldsvik at 58,7-58,9 m
-59	Voids at 59,8 m and 59,95 m
-60	Sample NGI / SINTEF by Vidar Kveldsvik at 60,05-60,8 m
-61	
-62	
-63	
-64	Possible 2 small zones of crushed rock
-65	
-66	Sample NGI / SINTEF by Vidar Kveldsvik at 66-66,3 m
-67	
-68	Voids at 68,95 m
-69	Sample NGI / SINTEF by Vidar Kveldsvik at 69,45-70 m
-70	
-71	
-72	
-73	
-74	
-75	Voids at 75,1 m
-76	
-77	
-78	Some eye structure in the gneiss
-79	
-80	Most fractures (especially foliation parallel) occur in biotite (mica) rich layers in the bedrock
-81	

Depth (m)	Comments
-82	
-83	
-84	
-85	
-86	Void at 86,5 m
-87	Folded
-88	Sample for bedrock type and heat conductivity 024907 at 88,2-88,35 m. Pictures 7226-7227
-89	
-90	
-91	
-92	
-93	chlorite lense at 93,3-93,5 m
-94	
-95	
-96	
-97	Voids at 97,08 m
-98	
-99	
-100	
-101	Eye structure in the gneiss
-102	Voids at 102,35 m and 102,45 m
-103	Voids at 103,22 m, 103,58 m and 103,75 m
-104	Voids at 104,42 m and 104,75 m
-105	Folded
-106	
-107	
-108	
-109	Feldspar vain at ca 109,70 m. Pictures 7223-7225

Depth (m)	Comments
-110	
-111	Tilt test at 111,05-111,4 m
-112	
-113	
-114	
-115	
-116	
-117	
-118	
-119	
-120	
-121	
-122	
-123	
-124	Fault rock at 124,44-124,5 m - cataclasite. Picture 7218-7222
-125	
-126	
-127	Folded
-128	
-129	Chlorite minerals
-130	
-131	Folded
-132	
-133	
-134	Tilt testing at 134,05-134,4 m. Chlorite rich between 134,6-134,7 m
-135	Chlorite at 135,7 m
-136	
-137	Chlorite rich BG. Picture 7217

Depth (m)	Comments
-138	Chlorite rich BG.
-139	
-140	
-141	Voids at 141,72-141,85 m
-142	Chlorite rich BG
-143	Sample for bedrock type and heat conductivity 024906. Pictures 7214-7216
-144	
-145	
-146	
-147	
-148	
-149	
-150	Quartz and chlorite vain at 150,2 m
-151	
-152	Fault rock at 152,42-152,54 m. Cataclasite. Pictures 7205-7213
-153	
-154	
-155	
-156	
-157	
-158	
-159	
-160	Quartz vain at 160,25 m
-161	Sample of fault rock 024905 - cataclasite? At 161,85-161,9 m. Pictures 7199-7204
-162	

BG = Biotittic gneiss
GG = granittic gneiss
DG = diorittic gneiss
PEG = pegmatite

*The fracture frequency is neither truncated or censored.
Fractures that is obviously made by the drilling process is not included.
This will (probably) give a higher fracture frequency than the background fractureing with at least 20 %.
** The fracture frequency is based on the in-situ fractures (estimations by Nicole Ragvin)

The bedrock is very heterogen and drawing the boundary between the different types is difficult.
The content of mafic minerals is given by ca %, also indicating the changes in the bedrock.
Where several bedrock types are indicated, there is a frequent change in bedrock, indicating it beenig even more heterogen.

KH-01-M 2005 - Middle borehole no. 1 inclined 60 degrees (Drillcore c1A)

Coordinates N6895731 E395615 Height above sea level ca: 520 m a.sl.

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed rock [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
0	GG	40			13	10	11
-1	GG	30-40			10	4	7
-2	GG	20-30			11	9,9	8
-3	GG	40 / 20			10	7 (7)	7
-4	GG	30			10	7 (8)	8
-5	GG	30 (60) 20			8	7	4
-6	GG	20-30 / 70			10	9,2	7
-7	BG (GG)	60	Crushed zone (0,5 m)		21	18	17
-8	BG (GG)	70 / 40-50 /70			21	18	19
-9	BG	60	Crushed zone (0,2 m)		16	18	14
-10	GG	40-50			10	8,6	8
-11	BG / GG / BG	70 / 40 / 60			14	11,3	11
-12	GG	40-50			7	7	7

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed rock [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-13	GG / BG / GG	40 / 60 / 50			9	7	5
-14	BG	60-70			7	6,5	4
-15	BG	60-70			6	6,5	4
-16	BG	70			19	21,4	19
-17	GG (BG)	50			9	7	6
-18	BG (GG)	40-50 / 60			13	7	11
-19	GG	40			6	7	5
-20	GG /BG	30-40 / 60			6	7	6
-21	BG / GG / BG	60 / 50 / 60	Voids		13	15,5	11
-22	GG / BG	50 / 60-70	Voids		12	15,5	11
-23	BG	70-60			15	15,5	15
-24	BG	60-70	Fault rock max 5 cm		24	15,5	24
-25	BG / GG / BG	60	Fault rock max 5 cm x2		16	15,5	13
-26	Sampled				9	9,7	
-27	GG	40			10	9	9
-28	GG	30			5	11 (7)	5
-29	BG	60-70			15	11	15
-30	BG				5	8,5	5
-31	GG	40-50			9	8	8
-32	BG / GG / BG	60 / 30 7 60			11	8	11
-33	GG	40-50			9	9,7	8
-34	BG	50			17	19	15
-35	GG	40			6	7	4
-36	BG (DG)	60			10	7 (8)	10
-37	BG	60	Gouge / clay max 2 cm		4	7	4
-38	GG	40			8	7	7
-39	GG	40			6	7	6
-40	GG	40			6	7	6

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed rock [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-41	GG	20			8	9,2	8
-42	GG / BG	0 / 30 / 60 / 30 / 70			5	4	5
-43	GG	60 / 40 / 60 / 30-40			6	4	5
-44	GG	30			5	4	2
-45	BG (GG)	40 / 50			6	4	6
-46	BG (GG)	60			8	4	7
-47	GG	30-40			4	4	3
-48	GG	40			2	4	2
-49	GG	20			6	5,5	4
-50	GG	15			5	5,5	3
-51	GG	20-30			7	5,5	7
-52	GG	20-40			11	12,4	11
-53	GG	15			4	5,5	1
-54	Sampled				6	5,5	
-55	GG	30			7	5,5	7
-56	GG	40			5	8,5	5
-57	GG (BG)	50			8	8,5	7
-58	GG (BG)	40-50			12	8,5	12
-59	GG (BG)	40 (50)			9	8,5	7
-60	GG	40			5	8,5	5
-61	GG (BG)	50-60			4	8,5	4
-62	GG (BG)	60			7	8,5	6
-63	BG (GG)	50-60			9	9,4	9
-64	BG	60			6	9,5	6
-65	BG	50-60			7	9,5	7
-66	BG (GG)	50-60			10	9,5	8
-67	Sampled				9	9,5	
-68	BG (GG)	50			9	9,5	8
-69	GG	50-60			10	9,7	9
-70	GG (BG)	50 / 60			10	12,2	8
-71	GG	30-40	Voids		6	5	6

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed rock [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-72	GG / BG	60 / 60			5	5	4
-73	BG (GG)	50			4	5	3
-74	BG (GG)	50-60			4	5	4
-75	BG (GG)	60			4	5	3
-76	BG (GG)	50	Voids		5	5	5
-77	DG / GG	50 / 40			8	6,5	7
-78	PEG / GG	40			8	6,5	8
-79	GG	40 / 50 / 60			7	6,5	7
-80	GG	50-60			5	2,7	5
-81	GG	30-40			7	1	
-82	GG	20-30			7	1	1
-83	GG	20-30			3	1	
-84	GG	25			1	3	
-85	GG	20			3	3	
-86	GG	30-20			4	3	
-87	GG	30			3	3	
-88	GG	20 / 30 / 40			4	3	
-89	GG	40 / 30			8	3	7
-90	GG	30			4	3	3
-91	(PEG) GG	40			6	2	6
-92	GG	30			3	2	1
-93	GG	40			3	2	3
-94	GG	40			2	2	
-95	GG	30-40			4	2	3
-96	GG / BG	40 / 60			8	7,8	6
-97	BG	60-70	Voids		8	10	6
-98	BG (GG)	50-60			10	10	8
-99	BG (GG)	40-50			6	5,6	5
-100	BG (GG)	50			5	3,7	3
-101	GG (BG)	40			6	3,7	4
-102	GG / BG	30 / 40	Fault rock - protocataclasite max 20 cm		2	3,7	1
-103	GG	50 / 40			6	3,7	4

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed rock [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-104	GG / BG / GG	20 / 50 / 20			4	3,7	4
-105	GG (BG)	40			4	2,5	2
-106	GG (BG)	40			5	2,5	3
-107	BG /GG	60-70 / 50			4	2,5	3
-108	GG (BG)	40-50			6	2,5	2
-109	GG (BG)	50			3	2,5	3
-110	GG (BG)	50			4	2,5	4
-111	GG	40			6	2,5	5
-112	GG	40			4	3,5	4
-113	GG	30			3	3,5	1
-114	GG	30-40			4	3,5	4
-115	GG	40			6	3,5	3
-116	GG	30-40			6	3,5	4
-117	GG	40			5	3,5	3
-118	GG	30			4	3,5	3
-119	GG / BG	35 / 45			6	1,5	3
-120	BG (GG)	40-50			4	1,5	4
-121	BG (GG)	50			2	1,5	2
-122	BG	50			4	1,5	3
-123	BG (GG)	65 / 55			3	1,5	1
-124	BG / GG / BG	55 / 35 / 60			3	1,5	3
-125	PEG / BG	60-70			6	1,5	4
-126	BG	60			3	2,5	3
-127	BG	60			5	2,5	3
-128	BG	60			9	2,5	9
-129	BG / GG	55 / 20			5	2,5	5
-130	GG	35			4	2,5	3
-131	GG	40			2	2,5	1
-132	GG	30-40			3	2,5	3
-133	DG (GG)	30-40			4	1,5	1
-134	DG	20-30			4	1,5	2
-135	BG	70			8	1,5	7
-136	DG / BG	40 / 60			5	1,5	3
-137	BG	60-70			4	1,5	4

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed rock [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-138	BG / DG	65 / 30			4	1,5	4
-139	DG	30-40			7	1,5	3
-140	DG / GG	40 / 25			5	2	3
-141	GG / BG	30 / 75			2	2	1
-142	BG / GG	75 / 45			4	2	3
-143	GG	40			2	2	2
-144	GG	40			2	2	1
-145	GG	30-40			7	2	6
-146	GG	20-30			5	2	1
-147	GG	40 / 20 / 40			6	3,5	4
-148	GG	30-40			6	3,5	3
-149							
-150							

KH-01-M 2005 - Middle borehole no. 1 inclined 60 degrees (Drillcore c1A)

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Samples (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample
0	2		54				
-1	3		82				
-2	3		42				
-3	3		70				
-4	2		70				
-5	4		70				
-6	3		60				
-7	4		22				
-8	2		22				
-9	2		22				
-10	2		58				
-11	3		27				
-12			67				

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Samples (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample
-13	4		67				
-14	3		64				
-15	2		64				
-16			16				
-17	3		78				
-18	2		78				
-19	1		78				
-20			78				
-21	2		32				
-22	1		32				
-23			32	Sample 23,5-24 m		SINTEF	Vidar Kveldsvik
-24			32	Sample 24872 at 24,54-24,56 m	XRD, thin section	NGU	Iain Henderson
-25	3		32	ID 24873 at 25,41-25,45 m, ID 24874 at 25,84-25,9 m	XRD, thin section	NGU	Iain Henderson
-26			58	Sample 26-27 m		SINTEF	Vidar Kveldsvik
-27	1		61				
-28			43	Sample 28,5-28,9 m		SINTEF	Vidar Kveldsvik
-29			43				
-30			69	Sample 30,2-31 m		SINTEF	Vidar Kveldsvik
-31	1		74				
-32			74				
-33	1		63				
-34	2		0				
-35	2	80, 74, 68, 78	81				
-36		81, 80, 80, 70, 81, 83	81				
-37		67	81	Telt test 37-37,3 m. Sample NGI / SINTEF 37,1-37,8 m by Vidar kveldsvik. Sample NGU 37,85 m XRD - clay by Iain Henderson	Tilt test - Nicole Ragvin. XRD - Iain Henderson. Brazilian and Uniaxial - Vidar Kveldsvik	NTNU, SINTEF, NGU	Nicole Ragvin (NTNU), Iain Henderson (NGU), Vidar Kveldsvik (NGI)
-38	1	72, 84, 81, 36	81				
-39		82, 85, 75, 87	81				
-40		75, 87, 78, 84	81				

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Samples (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample
-41		80, 87, 80, 74	46				
-42		77, 84, 73, 80	84				
-43	1	78, 85, 78, 37	84				
-44	3	88, 77	84				
-45		60, 61, 86, 80,	84				
-46	1	70, 80, 80, 73	84				
-47	1	65, 84, 33	84				
-48			84				
-49	2	67, 61, 40, 42, 87	92				
-50	2	42, 77, 81	92				
-51		82, 80, 81, 83	92				
-52		84, 73, 82, 84, 87, 84	50				
-53	3	78, 79, 84, 62	87				
-54			87	Sample 54-55 m	Brazilian test + Uniaxial stress test	SINTEF	Vidar Kveldsvik
-55		86, 84, 79, 83, 86, 87	87				
-56		81, 82, 84, 84	70				
-57	1	72, 73, 84, 85	70				
-58		81, 77,	70				
-59	2	19, 84, 85	70				
-60		79, 86	70	Tilt test 60-60,5 m	Tilt test	NTNU	Nicole Ragvin (N
-61		81, 82	70	Sample 61,1-61,7 m	Brazilian test + Uniaxial stress test	SINTEF	Vidar Kveldsvik
-62	1	58, 65, 81, 62	70				
-63		61, 76, 78, 88	73				
-64		70, 57, 56, 64	74				
-65		56, 67, 83, 76	74				
-66	2	83, 47, 86, 77	74				
-67			74	Sample 67-68 m	n test + Uniaxial str	SINTEF	Vidar Kveldsvik
-68	1	84, 80, 64, 57,	74				
-69	1	82, 84, 52, 23	72				
-70	2	75, 68, 68, 48, 82, 65	34				
-71		86, 56, 74, 64	90				

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Samples (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample
-72	1	67, 68, 30, 42	90				
-73	1	67, 45, 64, 74	90				
-74		62, 69, 61, 27	90				
-75	1	70, 61, 20	90				
-76		66, 68, 66, 60	90				
-77	1	81, 84, 66, 67	86				
-78		89, 59, 77, 78, 84	86				
-79		73, 80, 60	86				
-80		82, 87, 50, 79	94				
-81	7	56,56	98				
-82	6	56, 63	98				
-83	3	66, 83	98				
-84	1	60	95				
-85	3	59, 77	95				
-86	4	84, 58	95				
-87	3	67, 76	95				
-88	4	55, 65	95				
-89	1	51, 76	95				
-90	1	25, 52	95				
-91		69, 77	100				
-92	2	54, 63	100				
-93		62, 80	100				
-94	2	84, 85	100				
-95	1	77, 88	100				
-96	2	34, 83, 81, 84	78				
-97	2	84, 48, 85, 68	70	Sample 024915 of voids at 97,25 - 97,3 m		NGU	Guri V. Ganerød
-98	2	63, 86, 61, 56, 70, 76	78				
-99	1	60, 80, 59, 81	91				
-100	2	58, 84, 61, 52	96				
-101	2	71, 72, 56	96				
-102	1	80, 74	96	Sample 024916 Protocataclasite 102-102,23 m	Thin section	NGU	Guri V. Ganerød
-103	2	55, 67, 40, 75	96				

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Samples (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample
-104		84, 85, 68, 84	96				
-105	2	69, 54, 72, 66	96				
-106	2	65, 87, 64, 74	96				
-107	1	63, 81, 82, 68	96				
-108	4	42, 47, 64, 78	96				
-109		74, 72, 72	96				
-110		84, 80, 81, 71	96				
-111	1	54, 63, 56, 65	96				
-112		80, 61, 83, 76	95				
-113	2	73, 67, 67	95				
-114		73, 78, 85, 83	95				
-115	3	62, 55, 62, 39, 79, 67	95				
-116	2	61, 80, 61, 80, 70	95				
-117	2	80, 62, 75, 86	95				
-118	1	84, 87, 75, 82	95				
-119	3	22, 53, 80, 50, 74, 68	98				
-120		68, 88, 76, 79	98				
-121		60, 82	98				
-122	1	76, 76, 90, 76	98				
-123	2	58, 81	98				
-124		63, 78	98				
-125	2	82, 83	98				
-126		72, 84, 59	97				
-127	2	76, 82, 84, 72	97				
-128		82, 83, 63,	97				
-129		85, 74, 67	97				
-130	1	74, 82	97				
-131	1	76, 62	97				
-132		72, 54, 60	97				
-133	3	86, 73,	98				
-134	2	53, 85	98				
-135	1	43, 21, 86, 55, 69	98				
-136	2	39, 63	98				
-137		75, 89, 72	98				

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Samples (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample
-138		82, 67	98	Tilt test 138,5-138,7	Tilt test	NTNU	Nicole Ragvin
-139	4	64, 66, 71	98				
-140	2	82, 78, 45, 81	97				
-141	1	44, 72	97				
-142	1	77, 59, 76, 49	97				
-143		84, 79	97				
-144	1	78,69	97				
-145	1	53, 72, 78, 70	97				
-146	4	59, 54, 73, 82	97				
-147	2	73, 75, 33, 32	91				
-148	3	74, 74, 39, 78	91				
-149							
-150							

KH-01-M 2005 - Middle borehole no. 1 inclined 60 degrees (Drillcore c1A)

Depth (m)	Remaining sample material	Comments
0		
-1		
-2		
-3		
-4		
-5		
-6		
-7		Crushed zone at ca 7,55 - 8 m. Possible core loss
-8		
-9		Crushed zone at 9,05 - 9,20 m - parallel to foliation
-10		
-11		
-12		

Depth (m)	Remaining sample material	Comments
-13		
-14		
-15		
-16		
-17		
-18		
-19		
-20		
-21		Voids at 21,8 og 21,9 m
-22		Voids at 22,75-23 m
-23	Destructed?	Sample NGI /SINTEF by Vidar Kveldsvik 23,5-24 m
-24	Minimal	Sample NGU - Fault rock 24,5 m by Iain Henderson / Guri V. Ganerød
-25	Minimal	Sample NGU - Fault rock 25,4 m by Iain Henderson / Guri V. Ganerød
-26	Destructed?	Sample NGI /SINTEF by Vidar Kveldsvik 26-27 m
-27		Folded
-28	Destructed?	Sample NGI / SINTEF 28,5-28,9 m by Vidar Kvelsdvik
-29		
-30	Destructed?	Sample NGI / SINTEF 30,2-31 m by Vidar Kveldsvik
-31		
-32		
-33		
-34		
-35		
-36		
-37	Destructed?	
-38		
-39		
-40		

Depth (m)	Remaining sample material	Comments
-41		
-42		
-43		
-44		
-45		
-46		
-47		
-48		
-49		
-50		
-51		
-52		
-53		
-54	Destructed?	Sample NGI / SINTEF 54-55 m by Vidar Kveldsvik
-55		
-56		Chlorite minerals at 56,65-56,85 m
-57		
-58		
-59		
-60	Yes	Tilt test 60-60,5 m
-61	Destructed?	Sample NGI / SINTEF 61,1-61,7 m by Vidar Kveldsvik
-62		
-63		
-64		
-65		
-66		Folded
-67	Destructed?	Sample NGI / SINTEF 67-68 m by Vidar Kveldsvik
-68		
-69		Folded
-70		
-71		Voids in Qtz-vain at 71,7 m Pictures 7322 +7323

Depth (m)	Remaining sample material	Comments
-72		
-73		
-74		
-75		
-76		Voids at 76,3 and 76,4 m
-77		
-78		
-79		
-80		
-81		
-82		
-83		
-84		
-85		
-86		
-87		
-88		
-89		
-90		
-91		
-92		
-93		
-94		
-95		
-96		
-97	Yes	Sample 024915 of voids at 97,25 - 97,3 m - pictures 7324-7327
-98		
-99		
-100		Chlorite at 100,8-100,9 m
-101		
-102	Yes	Sample 024916 Protocataclasite 102-102,23 m - Picture 7328-7332
-103		

Depth (m)	Remaining sample material	Comments
-104		
-105		
-106		
-107		
-108		
-109		
-110		
-111		
-112		
-113		
-114		
-115		
-116		
-117		
-118		
-119		
-120		
-121		
-122		
-123		
-124		
-125		
-126		
-127		
-128		
-129		
-130		
-131		
-132		
-133		
-134		
-135		Chlorite at 135,65-136,10 m
-136		
-137		

Depth (m)	Remaining sample material	Comments
-138	Yes	Tilt test 138,5-138,7
-139		
-140		
-141		Chlorite rich BG
-142		Chlorite rich BG
-143		
-144		
-145		
-146		
-147		Fracture with clay x 2 147,6-147,7 m (33 and 32 degrees anglel)
-148		**End at 148,65 m**
-149		
-150		

BG = Biotittic gneiss
GG = granittic gneiss
DG = diorittic gneiss
PEG = pegmatite

*The fracture frequency is neither truncated or censored.
Fractures that is obviously made by the drilling process is not included.
This will (probably) give a higher fracture frequency than the background fractureing with at least 20 %.
** The fracture frequency is based on the in-situ fractures (estimations by Nicole Ragvin)

The bedrock is very heterogen and drawing the boundary between the different types is difficult.
The content of mafic minerals is given by ca %, also indicating the changes in the bedrock.
Where several bedrock types are indicated, there is a frequent change in bedrock, indicating it beenig even more heterogen.

KH-02-M 2005 - Middle borehole no. 2 - 2005 vertical (Drillcore c1B)

Coordinates N6895731 E395615 **Height above sea level ca:** 520 m a.sl.

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed rock [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
0	DG (GG)	20-30			11	11	9
-1	DG / GG	20-30			9	11	6
-2	DG	40			12	11	10
-3	DG	30-40			6	5,8	6
-4	GG	40			3	1,5	1
-5	GG	30-40			2	1,5	2
-6	GG	30			3	1,5	3
-7	GG / DG	20 / 40			11	7,5	8

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed rock [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-8	BG	65 / 50			19	18,5	16
-9	BG	60-70			20	18,5	19
-10	GG	40-50			4	4	3
-11	GG / BG	55 / 65			9	7,4	9
-12	BG / GG	70 / 55			14	12,5	14
-13	GG / BG	55 / 60	Voids		12	12,5	9
-14	BG (GG)	50			11	11	8
-15	GG	50-60			7	3,3	
-16	GG / BG	50 / 60			8	7,5	8
-17	BG / GG	60 / 40	Voids		8	3,3 (4)	8
-18	GG / BG / GG	40 / 70 / 40			4	3,7	4
-19	GG / PEG	40 / 5			11	13,4	
-20	PEG / GG / BG	5 / 40 / 60			6	15,5	4
-21	BG / GG	60 / 30			11	12,7	10
-22	GG	30			7	6,7	
-23	GG	30			5	6,7	1
-24	GG	30			12	6,7	
-25	GG	30			7	6,7	4
-26	GG / BG / GG	30 / 60 / 30			7	9,5	4
-27	GG / BG / GG	35 / 70/ 35			11	11,3	7
-28	BG	70	Gouge / clay max 2 cm		15	15,5	
-29	BG (DG)	40-50	Voids		15	13,9	
-30	GG	25			5	4,8	
-31	GG	20	Voids		10	10,3	
-32	GG / BG	20 / 55			11	10,3	
-33	GG	40-30	Breccia / gouge x2		12	10,3	
-34	GG	25	Crushed zone max 10 cm		11	10,3	
-35	BG	60			10	10,5	8
-36	BG / GG	60 / 40			9	10,5	9

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed rock [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-37	GG	30-40			9	11,3	7
-38	BG	60-70			11	16	9
-39	GG	40-50			14	16	3
-40	GG	40			10	11,3	2
-41	GG	40-50			7	6,5	4
-42	GG	40			6	9,5	6
-43	BG / GG	60 / 40			9	9,5	9
-44	GG / BG	40 / 50			11	9,5	10
-45	GG	40			7	9,5	7
-46	GG	30-40			10	9,5	8
-47	GG	30-40	Gouge / clay max 2 cm		9	9,5	8
-48	GG	30-40			7	9,5	7
-49	DG	40-50			9	8,5	8
-50	GG	30			6	4,5	3
-51	GG	30	Red staining		6	4,5	3
-52	GG	30			3	4,5	2
-53	GG	30			5	4,5	5
-54	DG	30-40			3	4,5	3
-55	GG / DG	20 / 30			5	4,5	4
-56	GG	50-60			5	5	4
-57	GG / BG / GG	60 / 70 / 50			7	6	7
-58	GG	40			7	5	5
-59	GG	30-40			7	8	6
-60	GG	35			5	5	5
-61	GG	40-30			7	7	7
-62	GG	40			7	9	6
-63	GG	40-50	Voids		8	11	6
-64	GG	40-60			9	11	8
-65	GG	45 / 35			9	8	9
-66	GG	20	Voids		5	3,5	5
-67	GG	20	Voids		3	3,5	1

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed rock [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-68	BG / GG	70 / 40			9	7,8	9
-69	GG	30-40	Voids		8	8	8
-70	GG	15			5	4,6	5
-71	DG	40-50			4	4,6	4
-72	GG	30-40			3	4,6	3
-73	DG	50-60			8	5,9	6
-74	DG	50-60			8	7	7
-75	DG	50			8	7	6
-76	DG	50	Gouge / clay max 2 cm		4	7	4
-77	GG	30			7	12	6
-78	GG (BG)	40			13	12	13
-79	GG	40 / 20			9	7,2	5
-80	GG	30			9	7,3	9
-81	GG	35			7	9	7
-82	GG (BG)	60			9	9	9
-83	GG	50			10	9	10
-84	GG	20			6	7,5	6
-85	GG	40-50			9	7,5	9
-86	GG	40-50			5	6	5
-87	GG	60			4	2,5	4
-88	GG	40			2	2,5	
-89	BG	70			6	4,3	4
-90	BG	70			8	8,5	6

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed rock [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-91	BG	60-70			7	5	6
-92	BG	70			5	5	4
-93	DG (GG)	50-60			12	12,4	9
-94	DG (GG)	50-60			16	14	14
-95	DG	50-60			4	9,2	2
-96	DG	40-50			4	6	4
-97	GG	30-40			10	9,9	9
-98	BG / GG / BG	60 / 40 / 70			10	4,5	8
-99	GG / BG	40 / 60			3	4,5	3
-100	BG	70			7	4,5	6
-101	GG	40-50			4	4,5	4
-102	GG	50-60			3	4,5	3
-103	GG / BG	45 / 60			4	4,5	4
-104	BG	70			6	4,5	6
-105	BG	70-80	Voids		5	5	3
-106	BG	70-80	Voids		7	5	6
-107	BG / GG	70 / 40			8	5	8
-108	GG / BG	40 / 60			7	5	6
-109	BG	70-80			8	5	8
-110	BG (GG)	60			5	5	4
-111	BG (GG)	60			3	5	3
-112	BG (GG)	60	Voids		9	2,5	8
-113	BG	70-80	Voids		2	2,5	2
-114	BG	70-80	Voids		4	2,5	4
-115	BG / GG	65 / 55			3	2,5	
-116	GG (BG)	60			2	2,5	2
-117	GG	40-50			2	2,5	2

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed rock [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-118	BG / GG	50 / 35			4	2,5	3
-119	GG	15 / 40			3	2,5	2
-120	GG	55			5	2,5	5
-121	BG	60			6	2,5	6
-122	BG	70			3	2,5	3
-123	BG	70			3	2,5	3
-124	BG	70			3	2,5	2
-125	BG	70			5	2,5	3
-126	BG	70			4	3,5	4
-127	BG	60-70	Voids		7	3,5	4
-128	BG (GG)	60			5	3,5	4
-129	BG	50-60			6	3,5	6
-130	DG	40			2	3,5	1
-131	DG	50			3	3,5	1
-132	DG	65			3	3,5	3
-133	GG / BG	50 / 60			3	1	1
-134	GG	60 / 30			3	1	3
-135	BG	55			2	1	2
-136	BG	60			2	1	2
-137	BG	70			2	1	2
-138	BG	70			4	1	3
-139	BG	70-80			3	1	3
-140	BG / GG / BG	75 / 55 / 70			2	2	2
-141	BG / GG / BG	70 / 30 / 64			3	2	2
-142	BG	60-70			2	2	2
-143	BG	60-70			3	2	3
-144	BG	70-80			2	2	1
-145	BG	70-80			2	2	2
-146	DG	60			4	2	4

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed rock [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-147	DG / BG	50 / 60			3	3	
-148	DG	50	Voids		3	3	
-149	DG	40-50			3	3	
-150	DG	45			3	3	

KH-02-M 2005 - Middle borehole no. 2 - 2005 vertical (Drillcore c1B)

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Samples (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample	Remaining sample material
0	2		62					
-1	3		62					
-2	2		62					
-3			81					
-4	2		96					
-5			96					
-6			96					
-7	3		69					

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Samples (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample	Remaining sample material
-8	3		20					
-9	1		20					
-10	1		92					
-11			69					
-12			34					
-13	3		34					
-14	3		56					
-15	7		56					
-16			70					
-17			88					
-18			85					
-19			22					
-20	2		57					
-21	1		44					
-22	7		83					
-23	4		83					
-24	12		83					
-25	3		83					
-26	3		57					
-27	4		40					
-28			32		XRD, thin section	NGU	Iain Henderson	Minimal
-29			41					
-30			90					
-31			48					
-32			48					
-33			48		Thin section, XRD	NGU	Iain Henderson	Minimal
-34			48		XRD, thin section	NGU	Iain Henderson	Minimal
-35	2		53					
-36			53					

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Samples (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample	Remaining sample material
-37	2		50		XRD, thin section	NGU	Iain Henderson	Minimal
-38	2		31					
-39	11		31					
-40	8		59					
-41	3		86					
-42			61					
-43			61					
-44	1		61					
-45			61					
-46	2		61					
-47	1		61		XRD, thin section	NGU	Iain Henderson	Minimal
-48			61					
-49	1		61					
-50	3		89					
-51	3		89					
-52	1		89					
-53			89					
-54			89					
-55	1		89					
-56	1		82					
-57			73					
-58	2		84					
-59	1		77					
-60			70					
-61			91					
-62	1		71					
-63	2		61					
-64	1		61					
-65			77					
-66			100					
-67	2		100					

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Samples (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample	Remaining sample material
-68			90					
-69			89					
-70			92					
-71			92					
-72			92		XRD, thin section	NGU	Iain Henderson	Minimal
-73	2		82					
-74	1		74					
-75	2		74					
-76			74		XRD, thin section	NGU	Iain Henderson	Minimal
-77	1		50					
-78			50					
-79	4		80					
-80			79					
-81			67					
-82			67					
-83			67					
-84			87	84,45-84,64	Heat conductivity, Triaxial testing	NGU, Sintef	Guri Venvik Ganerød (NGU), Guro Grøneng (NTNU)	Yes
-85			87					
-86			89					
-87			94	87,70-87,93	Triaxial test	Sintef	Guro Grøneng (NTNU)	
-88			94	88,05-88,88	Tilt test, Triaxial test	NTNU, Sintef	Nicole Ragvin (NTNU), Guro Grøneng (NTNU)	Yes
-89	2		84					
-90	2		60					

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Samples (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample	Remaining sample material
-91	1		96	91,27-91,43	Triaxial test	Sintef	Guro Grøneng (NTNU)	
-92	1		96	92,17-92,87	Tilt test, Triaxial test	NTNU, Sintef	Nicole Ragvin (NTNU), Guro Grøneng (NTNU)	Yes
-93	3		41					
-94	2		29					
-95	2		66	95,50-95,80	Triaxial test	Sintef	Guro Grøneng (NTNU)	
-96			90		Heat conductivity	NGU	Guri Venvik Ganerød (NGU)	Yes
-97	1		70					
-98	2		92					
-99			92					
-100	1		92					
-101			92					
-102			92					
-103			92					
-104			92					
-105	2		91					
-106	1		91					
-107			91					
-108	1		91					
-109			91					
-110	1		91					
-111			91					
-112	1		97					
-113			97					
-114			97					
-115	3		97					
-116			97					
-117			97					

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Samples (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample	Remaining sample material
-118	1		97					
-119	1		96					
-120			96					
-121			96					
-122			96					
-123			96					
-124	1		96					
-125	2		96					
-126			94					
-127	3		94					
-128	1		94					
-129			94					
-130	1		94					
-131	2		94					
-132			94					
-133	2		99					
-134			99					
-135			99					
-136			99					
-137			99					
-138	1		99					
-139			99					
-140			99					
-141	1		99					
-142			99					
-143			99					
-144	1		99					
-145			99		Heat conductivity	NGU	Guri Venvik Ganerød (NGU)	Yes
-146			99					

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Samples (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample	Remaining sample material
-147			98	147-147,67	Tilt test, Triaxial test	NTNU, Sintef	Nicole Ragvin (NTNU), Guro Grøneng (NTNU)	Yes
-148			98	148,32-148,68	Triaxial test	Sintef	Guro Grøneng (NTNU)	
-149			98					
-150			98					

KH-02-M 2005 - Middle borehole no. 2 vertical 2005 (Drillcore c1B)

Depth (m)	Comments
0	
-1	
-2	Folded
-3	
-4	Folded
-5	Folded
-6	
-7	Folded

Depth (m)	Comments
-8	Folded
-9	
-10	Banded gneiss - eye structure
-11	
-12	
-13	voids at 13,65 m
-14	
-15	
-16	
-17	Voids at 17,15 m
-18	
-19	
-20	
-21	
-22	
-23	Some eye structures in the gneiss
-24	Folded
-25	
-26	
-27	
-28	Sample of gouge / clay - sampled in the field by Iain Henderson
-29	Many voids, especially at 29,1-29,6 m
-30	
-31	Folded. Voids at 31,45-31,65 m
-32	
-33	Sample of breccia / gouge at 33,05-33,15 m and sample of breccia at 33,5-33,6 m - sampled in the field by Iain Henderson
-34	Crushed zone at 34,65-34,7 m
-35	Fracture with clay at 35,35 m
-36	

Depth (m)	Comments
-37	
-38	
-39	
-40	Folded
-41	
-42	
-43	
-44	
-45	
-46	
-47	Sample of clay - sampled in the field by Iain Henderson
-48	
-49	
-50	
-51	Red staining and epidote vaining at 51,25-51,35 m - pictures 7239-7242
-52	
-53	
-54	
-55	
-56	
-57	
-58	
-59	
-60	
-61	
-62	
-63	Voids at 63,15 m, 63,25 m and 63,65-63,72 m
-64	
-65	
-66	Voids at 66,62 m
-67	Folded. Voids at 67,85 m

Depth (m)	Comments
-68	Folded
-69	Folded. Voids at 69,6 m
-70	
-71	
-72	
-73	
-74	
-75	
-76	Samples of clay in fractures for XRD at 76,65 m og 76,8 m
-77	
-78	Fracture with clay at 78,12 m
-79	
-80	
-81	
-82	
-83	
-84	Sample nr 24928
-85	
-86	
-87	
-88	Tilt test ved 88,6-89 m
-89	Epidote vain at 89,8 m
-90	Epidote vain at 90,7 m

Depth (m)	Comments
-91	Epidote vain at 91,75 m
-92	Tilt test at 92,45-92,7 m
-93	
-94	
-95	
-96	Sample nr 24927
-97	
-98	
-99	
-100	
-101	
-102	
-103	
-104	
-105	Voids at 105,4 m, chlorite rich biotite gneiss
-106	Voids at 106,30 m, chlorite rich biotite gneiss
-107	
-108	
-109	
-110	
-111	
-112	voids at 112,4 m
-113	Voids at 113,75 m and 113,9-114 m
-114	Several areas with voids
-115	
-116	Folded
-117	Folded

Depth (m)	Comments
-118	
-119	
-120	
-121	
-122	
-123	
-124	
-125	Folded
-126	
-127	Voids at 127,85 m
-128	
-129	
-130	
-131	Picture 7243-7246 large chlorite crystals in quartz?
-132	
-133	
-134	
-135	
-136	
-137	
-138	
-139	
-140	
-141	
-142	
-143	
-144	chlorite rich BG
-145	Sample nr 24926
-146	

Depth (m)	Comments
-147	Tilt test at 147,1-147,5 m. Chlorite rich BG
-148	Voids at 148,85 m
-149	
-150	Pegmatites between 150,35-150,60 m

BG = Biotittic gneiss
GG = granittic gneiss
DG = diorittic gneiss
PEG = pegmatite

*The fracture frequency is neither truncated or censored.
Fractures that is obviously made by the drilling process is not included.
This will (probably) give a higher fracture frequency than the background fractureing with at least 20 %.
** The fracture frequency is based on the in-situ fractures (estimations by Guro Grøneng)

The bedrock is very heterogen and drawing the boundary between the different types is difficult.
The content of mafic minerals is given by ca %, also indicating the changes in the bedrock.
Where several bedrock types are indicated, there is a frequent change in bedrock, indicating it beenig even more heterogen.

KH-01-N 2005 - Lower borehole no. 1 - 2005 (Drillcore c3)

Coordinates N6895313 E395830 Height above sea level ca: 230 m a.sl.

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed core [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
0			Core loss				
-1			Core loss				
-2	GG	40	Core loss		3	12	3
-3	GG	40			8	6	4
-4	GG	30			10	9	8
-5	GG	30			8	4	5

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed core [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-6	GG	40			10	7	8
-7	GG	25			7	5	5
-8	GG	25		8	10	11	7
-9	GG	30		12	10	10	7
-10	GG	15			7	8	3
-11	GG / DG	20 / 30			9	2	7
-12	DG	35			21	16	20
-13	DG	35			7	7	6
-14	DG	15			5	7	4
-15	DG	15		2	7	8	6
-16	BG	70			13	8	11
-17	BG	60-70	Fault rock		9	19	9
-18	BG	60-70	crushed rock / fault rock?	15	15	12	11
-19	BG	70-80	Crushed rock	24	7	8	7
-20	BG	70-80	Crushed rock	25	7	2	6
-21	BG	70			7	7	3
-22	BG	70-80	Crushed rock	63	50	6	

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed core [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-23	BG	70	Small zones of crushed rock	2	10	8	8
-24	BG	70			6	7	3
-25	BG	70			5	5	4
-26	BG (DG)	50-60			5	4	3
-27	BG / DG	20	Small zones of crushed rock		11	11	8
-28	DG	40		2	4	3	4
-29	DG	40-50			6	3	6
-30	DG	40-50			3	3	3
-31	DG	40-50			5	5	2
-32	DG	30-40			8	4	6
-33	DG / GG	40			6	3	6
-34	GG	40	Voids		9	6	9
-35	GG	30-40			6	2	6
-36	GG				2	2	
-37	GG				2	7	
-38	GG / BG	45 / 65	Small zones of crushed rock	4	14	11	14
-39	BG / GG	65 / 25	Small zones of crushed rock	6	10	10	
-40	GG / BG	20 / 70	Zones of crushed rock	15	12	11	10
-41	GG	40	Small zones of crushed rock	7	13	10	11
-42	GG	55	Small zones of crushed rock	9	14	10	14

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed core [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-43	GG	50	Small zones of crushed rock	7	5	5	5
-44	GG	40-50			5	4	5
-45	GG / BG	40 / 60			9	3	8
-46	BG	60			5	4	4
-47	BG	60-70			3	1	2
-48	DG (BG)	50-60			4	3	3
-49	Ultra mafic	80-90		2	3	3	
-50	DG	20-30			5	2	4
-51	DG	30	Zone of crushed rock	33	13	12	11
-52	DG	30-40	Voids		4	0	2
-53	DG	30			5	1	4
-54	DG	30-40	Voids		4	2	3
-55	DG	40	Voids		4	1	3
-56	DG	40			4	0	2
-57	DG	40-50			6	0	5
-58	DG	40-50		3	6	3	5
-59	DG	50-60			1	1	1
-60	DG	60			6	5	6
-61	BG / DG	70 / 55			8	3	7
-62	DG	55	Small highly fractured zone		15	6	
-63	DG	30	Highly fractured zone	2	25	5	5
-64	DG	50-60			7	5	7

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed core [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-65				5	3	3	
-66	DG	50			4	2	4
-67					2	2	
-68	DG	40-50			3	0	3
-69	DG	50			3	2	2
-70	BG	60			5	5	5
-71	DG	45			6	5	5
-72	DG	40			3	2	3
-73	DG	50			3	2	2
-74	DG	40			5	1	2
-75	DG	40			2	0	
-76	DG	40-50			7	5	1
-77	DG	40			5	3	1
-78	DG	50			3	1	2
-79	DG	35	Voids		5	3	3
-80	DG	30			4	2	3
-81	DG	40-50			8	6	6
-82	DG	40			5	1	5
-83	DG	40			3	0	3
-84	DG	30-40			3	0	
-85	DG	55			4	2	4
-86	DG / GG / BG	60 / 50 / 70			4	4	1
-87	DG	40			2	0	1

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed core [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-88	DG	55			4	0	2
-89	DG	55			2	0	1
-90	DG	50			3	0	2
-91	DG (BG)	60			7	4	7
-92	DG (BG)	50			5	1	3
-93	DG	50			8	6	6
-94	DG	40			4	3	3
-95	DG	50			4	3	3
-96	DG	50-60			4	3	4
-97	DG	30-40			3	3	3
-98	GG	40	Crushed rock	7	6	5	4
-99	GG	40			5	3	5
-100	GG	30			5	2	5
-101	GG	30-40		4	8	5	8
-102	GG	30			3	2	3
-103	GG	20-30			3	2	2
-104	GG	40			3	2	2
-105	DG (BG)	50			5	4	5
-106	BG	60	Crushed rock		4	3	4
-107	BG / DG	60 / 30			5	3	4
-108	DG / BG	40 / 60			7	4	7
-109	BG	60			4	1	4
-110	BG	60			5	4	4
-111	BG	60-70			2	1	2
-112	BG	60-70			5	4	4
-113	BG	50-60			3	3	3
-114	BG	55			9	11	9
-115	BG	70	Highly fractured zone + crushed zone		50	9	
-116	BG	60			6	2	5
-117	BG	65			4	2	2
-118	BG	60			2	2	2

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed core [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-119	BG	70			3	3	
-120	BG	60			6	1	6
-121	BG	60			5	4	3
-122	BG	70			3	2	3
-123	BG	55			4	2	3
-124	BG (GG)	60			4	1	2
-125	BG (GG)	50			4	1	4
-126	BG (GG)	60			2	1	1
-127	BG (GG)	60			3	3	3
-128	BG (GG)	60			2	2	1
-129	BG (GG)	50-60			4	5	4
-130	BG (GG)	60			4	4	4
-131	BG (GG)	60			5	5	4
-132	GG	5			2	3	1
-133	BG	60			5	5	2
-134	BG (GG)	60			3	5	1
-135	BG (GG)	50			3	4	2
-136	BG	60			7	9	5
-137	BG (GG)	60			3	3	3
-138	BG	70			4	5	4
-139	BG	70			5	5	2
-140	BG (DG)	50			2	4	1
-141	BG (DG)	50			3	4	3
-142	BG (DG)	45			2	3	1
-143	DG	40			4	4	4
-144	DG	20-30			3	3	3
-145	DG	20-30			1	1	1
-146	DG	20-30			4	4	4

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Crushed core [cm]	*Fracture frequency (January 2006)	**Fracture frequency (2005)	Foliation parallel fractures
-147	DG	20-30			3	3	3
-148	DG	30			3	2	2
-149	DG	40			2	4	1
-150	DG	60			1		1
-151							

KH-01-N 2005 - Lower borehole no. 1 - 2005 (Drillcore c3)

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample	Remaining sample material
0								
-1								
-2		33, 33, 56,	30					
-3	4	74, 60, 47, 40, 83, 33, 60, 34, 68,	34					
-4	2	43, 76, 46, 26, 71, 26, 48, 73, 59	49					
-5	3	77, 77, 35, 37, 38, 51, 45, 48,60	88					

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample	Remaining sample material
-6	2	81, 49, 48, 42, 83, 56, 57, 45, 64, 55, 60, 57	61					
-7	2	65, 32, 67, 47, 46, 76	74					
-8	3	54, 47, 56, 50	44					
-9	3	42, 39, 35, 33, 82, 54, 53, 61	18					
-10	4	31, 50, 41	77	Sample 024902 at 10,95 m	XRD	NGU	Guri Venvik Ganerød (NGU)	Minimal
-11	2	63, 45, 59, 24, 54, 69, 75, 84, 20, 85	82					
-12	1	64, 60, 55, 53, 44, 55,	28					
-13	1	52, 64, 27, 85, 23	54					
-14	1	87, 81, 27	87					
-15	1	21, 82, 82, 47, 54, 75,	62	Sample 024903 at 15,80 m	XRD	NGU	Guri Venvik Ganerød (NGU)	Minimal
-16	2	74, 87, 63, 87	67					
-17			36	Sample 024904 at 17,20-17,35 m	Thin section	NGU	Guri Venvik Ganerød (NGU)	Yes
-18	4		56					
-19		60, 50, 70, 32, 71	61					
-20	1	76, 77, 79, 33, 80	72	Sample 024912 at 20,4-20,48 m.	Heat conductivity and thin section	NGU	Guri Venvik Ganerød (NGU)	Yes
-21	4		37					
-22			13					

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample	Remaining sample material
-23	2		27					
-24	3		58					
-25	1		87					
-26	2		82					
-27	3		43					
-28			96					
-29			89					
-30			99					
-31	3		92					
-32	2		89					
-33			93					
-34			73					
-35			90					
-36			90	Sample at 36,10-37 m	Brazilian test and Uniaxial stress test	SINTEF	Vidar Kveldsvik (NGI)	Destructed?
-37			60	Sample at 37,3-37,9 m	Brazilian test and Uniaxial stress test	SINTEF	Vidar Kveldsvik (NGI)	Destructed?
-38			48					
-39			54					
-40	2		28					
-41	2		46					
-42			64					

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample	Remaining sample material
-43			77					
-44			80					
-45	1		70					
-46	1		83	Sample 24921 at 46,5-46,7 m	Heat conductivity	NGU	Guri Venvik Ganerød (NGU)	Yes
-47	1		96					
-48	1		87					
-49			81	Sample at 49-49,9 m	Brazilian test and Uniaxial stress test	SINTEF	Vidar Kveldsvik (NGI)	Destructed?
-50	1		97	Tilt test at 50,4-50,6 m	Tilt test	NTNU	Nicole Ragvin (NTNU)	Yes
-51	2		57	Sample 24917 at 51,1-51,38 m	Heat conductivity	NGU	Guri Venvik Ganerød (NGU)	Yes
-52	2		100	Sample 24918 at 52,6-52,78 m	Heat conductivity	NGU	Guri Venvik Ganerød (NGU)	Yes
-53	1		100					
-54	1		100					
-55	1		100					
-56	2		100					
-57	1		100					
-58	1		83	Sample 024911 at 58-58,18 m	Heat conductivity and thin section	NGU	Guri Venvik Ganerød (NGU)	Yes
-59			100					
-60			87					
-61	1		90					
-62			70					
-63			87					
-64			87					

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample	Remaining sample material
-65			96	Sample at 65-66 m	Brazilian test and Uniaxial stress test	SINTEF	Vidar Kveldsvik (NGI)	Destructed?
-66			100					
-67			100	Sample at 67-67,9 m	Brazilian test and Uniaxial stress test	SINTEF	Vidar Kveldsvik (NGI)	Destructed?
-68			100					
-69	1		92	Tilt test at 69,4-69,65 m. Sample 24919 at 69,68-69,93 m	Tilt test / Heat conductivity	NTNU / NGU	Nicole Ragvin (NTNU) / Guri Venvik Ganerød (NGU)	Yes
-70			72					
-71	1		87					
-72			100					
-73	1		95	Sample at 73,35 - 73,95 m	Brazilian test and Uniaxial stress test	SINTEF	Vidar Kveldsvik (NGI)	Destructed?
-74	3		100					
-75	2		100					
-76	6		73					
-77	4		100					
-78	1		100					
-79	2		100					
-80	1		100					
-81	2		78					
-82			100					
-83			100					
-84	3		100					
-85			100					
-86	3		100					
-87	1		94					

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample	Remaining sample material
-88	2		100					
-89	1		100					
-90	1		100					
-91			99					
-92	2		100					
-93	2		85	Sample 024910 at 93,45-93,60 m	Heat conductivity and thin section	NGU	Guri Venvik Ganerød (NGU)	Yes
-94	1		100					
-95	1		96					
-96			91					
-97			100					
-98	2		89					
-99			89					
-100			99					
-101			87					
-102			96					
-103	1		98					
-104	1		100					
-105			91					
-106			95					
-107	1		85					
-108			93					
-109			100					
-110	1		86					
-111			100					
-112	1		100					
-113			95					
-114			56					
-115			39					
-116	1		100					
-117	2		100					
-118			100					

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample	Remaining sample material
-119	3		95					
-120			100					
-121	2		91					
-122			100					
-123	1		100					
-124	2		100					
-125			100					
-126	1		100					
-127			100	Sample 024913 at 127,77-127,95 m	Heat conductivity and thin section	NGU	Guri Venvik Ganerød (NGU)	Yes
-128	1		100					
-129			100					
-130			91					
-131	1		87					
-132	1		100					
-133	3		100					
-134	2		97					
-135	1		93					
-136	2		67					
-137			100	Sample 24920 at 137,7-138 m	Heat conductivity	NGU	Guri Venvik Ganerød (NGU)	Yes
-138			91	Tilt test at 138,4-138,6 m	Tilt test	NTNU	Nicole Ragvin (NTNU)	Yes
-139	3		100					
-140	1		100					
-141			94					
-142	1		100					
-143			91	Sample 024914 at143,45-143,7 m	Heat conductivity and thin section	NGU	Guri Venvik Ganerød (NGU)	Yes
-144			100					
-145			100					
-146			91					

Depth (m)	Other fractures	Angle between fracture and core axis	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis performed	Who is in charge of sample	Remaining sample material
-147			100					
-148	1		100					
-149	1		100					
-150								
-151								

KH-01-N 2005 - Lower borehole no. 1 - 2005 (Drillcore c3)

Depth (m)	Comments
0	
-1	
-2	Core loss intil 2,7 m
-3	
-4	
-5	

Depth (m)	Comments
-6	
-7	
-8	Fracture with clay
-9	
-10	Sample of clay (gouge?) for XRD 024902 at 10,95 m. Clay on fractures
-11	Fracture with clay
-12	
-13	Fracture with clay
-14	Fracture with clay
-15	Sample of clay (gouge?) for XRD 024903 at 15,80 m. Clay on fractures
-16	Fractures with clay
-17	Fault rock - breccia/gouge at 17,20-17,35 m - sample 024904 - and 17,42-17,45 m. + fractures with clay
-18	Crushed rock - possibly fault rock at 18,4-18,52 m and crushed rock + clay at 18,92 - 19,20 m
-19	Crushed rock + clay at 18,92 - 19,20 m. Chlorite rich BG
-20	Sample for bedrock type and heat conductivity 024912 at 20,4-20,48 m. Chlorite rich BG. Crushed rock zone at 20,95-21 m
-21	
-22	Zone of crushed rock at 22,1-22,45 m and partly crushed at 22,7-23 m. Chlorite rich BG

Depth (m)	Comments
-23	Small zones of crushed rock with clay at 23,15 m and 23,18-23,22 m. Fracture with slickenline at 23,8 m. Dip of fracture 64 degrees. Lineation is oblique by 18 degrees - strike slip (down dip). Picture 7295
-24	Fractures with clay. Chlorite rich BG
-25	Picture of box 7278-7294
-26	Chande in BG bedrock - uncommon
-27	Small zone of crushed rock at 27,02-27,07 M (5 cm). Fractures with clay
-28	Pegmatite 5 cm
-29	
-30	
-31	
-32	
-33	
-34	Voids at 34,15 m
-35	
-36	
-37	Picture of box 7268-7277. Crushed zones
-38	Small zone of crushed rock at 38,95-39,05 m
-39	Small zone of crushed rock at 38,95-39,05 m, 39,11-39,13 m and 39,24-39,27 m
-40	Zones of crushed rock at 40,2-40,25 m, 40,4-40,5 m and 40,72-40,75 m
-41	Zone of crushed rock with clay at 41,35-41,4 m and foliation parallel highly fractured zone at 41,82-41,9 m. Fractures with clay
-42	Foliation parallel highly fractured zone at 42,07-42,15 m. Fractures with clay. Pegmatite vain - max 5 cm.

Depth (m)	Comments
-43	Zone of crushed rock with clay at 43,05-43,1 m - pictures 7264-7267. Fractures with clay
-44	Fracture with clay
-45	
-46	
-47	
-48	Pegmatite max 5 cm
-49	
-50	Tilt test at 50,4-50,6 m
-51	Highly fractures parallel to th foliation
-52	Voids at 52,3 m
-53	
-54	Voids at 54,05 m
-55	Voids at 55,75 m
-56	
-57	
-58	Sample of bedrock type and heat conductivity 024911. Picture 7262-7263
-59	Epidote mineralization at 59,7 m
-60	
-61	Pegmatite max 5 cm at 61,35 m
-62	Small highly fractured zone at 62,82-62,86 m
-63	Highly fractured zone at 63-63,15 m. Mica rich. Possible slide surface??
-64	

Depth (m)	Comments
-65	
-66	Pegmatite at 66,72-66,82 m
-67	
-68	
-69	Tilt test at 69,4-69,65 m
-70	
-71	Pegmatite at 71,35-71,50 m
-72	
-73	
-74	
-75	
-76	
-77	Pegmatite at 77,3 m, ca 5 cm
-78	
-79	Voids at 79,3 m
-80	
-81	
-82	
-83	
-84	
-85	Ultra mafic zone (chlorite) at 85,3-85,5 m - Picture 7249-7253
-86	
-87	Pegmatite at end of meter

Depth (m)	Comments
-88	
-89	
-90	
-91	
-92	
-93	Sample 024910 of bedrock type and heat conductivity at 93,45-93,60 m - Picture 7247-7248
-94	
-95	
-96	
-97	
-98	Zone of crushed rock in biotite layer at 98,6-98,72 m
-99	
-100	
-101	
-102	
-103	
-104	
-105	
-106	Crushed rock at 106,32-106,38 m
-107	
-108	Chlorite rich BG
-109	
-110	
-111	
-112	
-113	
-114	
-115	Hightly fractures zone parallel to foliation at 115-155,2 m crushed zone at 115,2-115,35 m
-116	
-117	
-118	Epidote vain at 118,45 m

Depth (m)	Comments
-119	Epidote vain at 119,47 m
-120	
-121	
-122	
-123	
-124	
-125	
-126	
-127	Sample 024913 of bedrock type and heat conductivity at 127,77-127,95 m
-128	
-129	
-130	
-131	
-132	
-133	
-134	
-135	
-136	Pegmatite at 136,55-136,68 m
-137	
-138	Tilt test at 138,4-138,6 m
-139	
-140	
-141	
-142	
-143	Sample 024914 of bedrock type and heat conductivity. Bedrock is folded
-144	Folded
-145	Folded
-146	Epidote vain at 146,55 m

Depth (m)	Comments
-147	
-148	Folded
-149	
-150	**End at 150,5 m**
-151	

BG = Biotittic gneiss
GG = granittic gneiss
PEG = pegmatite
Q= quartz
f=feldspar
";" = and
*The fracture frequency without crushed rock
Fractures that are obviously made by the drilling process are not included.
This will (probably) give a higher fracture frequency than the background fracturing with at least 20 %.
**Fracture frequency including crushed rock. For 1 m crushed rock--> FF = 50. 1 m breccia-->FF= 70. For 1 m clay--> FF = 90
The bedrock is very heterogenous and drawing the boundary between the different types is difficult.

The content of mafic minerals is given by ca %, also indicating the changes in the bedrock.
Where several bedrock types are indicated, there is a frequent change in bedrock, indicating it beenig even more heterogenous.
BB/GG= rock change within the 1 m interval
BB to GG= rock that is a mix of the two categories

KH-02-Ø 2006 - Upper borehole no. 2 2006

Meter depth	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency
0		?		100		
-1	PEG to BG	30		60	30	26
-2	BG	20		40		25
-3	BG/GG	10		30		10
-4	GG	10		15		4
-5	GG	10				4
-6	GG with some of BG	10				13
-7	foliated GG with PEG	10			15	15
-8	foliated GG with PEG	30			40	5
-9	Very foliated BG	60			60	5
-10	BG/DG	40			20	12

Meter depth	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency
-11	BG/DG	40			25	3
-12	BG with foliation	50				12
-13	BG with foliation	50				8
-14	BG with foliation	40			20	15
-15	BG with foliation	40			5	13
-16	BG with quartz veins/PEG	60			25	10
-17	BG	50			10	11
-18	BG	50				9
-19	BG	50			5	17
-20	BG	50			5	12
-21	BG+GG/PEG	20				14
-22	BG	50				9
-23	BG	40				11
-24	BG	40				11
-25	BG	40				15
-26	BG with foliation	40			10	10
-27	BG with foliation	40			25	11
-28	BG to GG	40-50			35	11
-29	BG to GG	40-50			75	6
-30	BG to GG	40-50			18	6
-31	BG to GG	40-50			30	9
-32	BG to GG	40-50			24	9
-33	BG to GG	40-50			31	10
-34	BG to GG	40-50				9
-35	BG to GG with foliation	40-50			24	6
-36	BG with Surface porosity	40-50				7
-37	BG with Surface porosity	40-50				8
-38	BG with Surface porosity	40-50			12	7
-39	BG with Surface porosity	40-50				5

Meter depth	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency
-40	GG with foliation	10			50	7
-41	GG/BG with cemented cracks	20				5
-42	PEG with BG. Transformed feldspar	20			50	6
-43	BG with Surface porosity	40			20	6
-44	BG with Surface porosity	40			3	11
-45	BG with Surface porosity	40			59	5
-46	GG to BG	20			3	10
-47	BG	50-60				9
-48	GG to GG	20				3
-49	GG	20-30				8
-50	GG	20-30		55		8
-51	BG, 51.25 - 51.50 clay, GG	60-70				9
-52	BG to GG, long cemented cracks	50				6
-53	BG to GG with opened former cemented cracks	50				4
-54	BG to GG with opened former cemented cracks	50				6
-55	GG	30				6
-56	BG	40				3
-57	BG	40				6
-58	BG with silty/clayish filling	40				5
-59	BG	50-60				7
-60	BG	40-50				14
-61	BG with PEG	30-40				8
-62	BG	40-50				8
-63	GG/BG	20-30				5
-64	BG to GG	30-40				7
-65	BG to GG	30-40				12
-66	BG	30-40				5
-67	BG with Surface porosity	40				3
-68	BG	40				2

Meter depth	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency
-69	BG to GG with transformed pink feldspar	30-40				4
-70	BG to GG with transformed pink feldspar	30-40				1
-71	BG to GG with transformed pink feldspar	30-40				1
-72	BG to GG with transformed pink feldspar	30-40				0
-73	BG to GG with transformed pink feldspar	30-40				2
-74	BG to GG with transformed pink feldspar	30-40				0
-75	BG to GG with transformed pink feldspar	30-40				1
-76	BG to GG with transformed pink feldspar, folded	30-40				0
-77	BG to GG with transformed pink feldspar, folded	30-40				0
-78	BG to GG with transformed pink feldspar, folded	30-40				0
-79	BG to GG with transformed pink feldspar, folded	30-40				0
-80	BG with PEG/feldspar	40-50				2
-81	BG with Surface porosity	40-50				6
-82	BG with Surface porosity foliated	40-50				5
-83	BG with Surface porosity folded	40-50				3
-84	BG with Surface porosity	40-50				6
-85	GG to BG	30-40				5
-86	GG to BG	30-40				5
-87	GG to BG	30-40				4
-88	GG to BG Surface porosity	30-40				3
-89	BG Surface porosity	30-40				2
-90	BG Surface porosity	30-40				5
-91	GG	20				2
-92	GG	20				2
-93	foliated GG	20-30				4
-94	foliated BG	20-30				9
-95	foliated BG	30-40				5
-96	foliated BG with PEG	40				5
-97	foliated and folded GG/BG	20-30				3

Meter depth	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency
-98	Light BG with PEG	20-30				6
-99	BG with Surface porosity and foliation	40				6
-100	folded BG with PEG	30-40				3
-101	folded BG with PEG	30-40				5
-102	folded BG with PEG	30-40				7
-103	BG/DG	30-40				6
-104	BG with Surface porosity	30-40				6
-105	BG with PEG	40				6
-106	BG to GG with Surface porosity	40-50				10
-107	GG	20				0
-108	GG	20				2
-109	GG	20-30				0
-110	GG	20-30				0
-111	GG	20-30				2
-112	GG	20-30				2
-113	GG	20-30				2
-114	GG to DG	30-40			5	6
-115	BG to GG	40-50			5	2
-116	BG with Q-bands	40-50				5
-117	foliated BG	40-50				3
-118	GG with strong foliation	40-50				7
-119	GG	30		15	18	3
-120	GG	30				3
-121	BG to GG	30-40				3
-122	BG to GG, PEG	30-40				2
-123	Strongly foliated BG	30-40				3
-124	GG to BG with foliation	30-40				3
-125	GG to BG with foliation	30-40			5	5
-126	BG with Q-bands	30		10		3

Meter depth	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency
-127	BG Clay layer of 10 cm	40				4
-128	GG to BG sandy fractures				5	3
-129	BG with chlorite Surface porosity	60				1
-130	GG to BB	30				2
-131	BG sandy cracks with slickensides	50				3
-132	BG Surface porosity	50				3
-133	Bluegrey BG	40-50				9
-134	BG	50-60				4
-135	Clearly foliated BG.	40-50				3
-136	BG	50				5
-137	foliated BG	50				9
-138	BG with chlorite	50				0
-139	BG with chlorite	60				4
-140	foliated BG	30-40				10
-141	BG with chlorite	30-40				3
-142	BG with chlorite	30-40				8
-143	BG with chlorite	30-40				5
-144	BG	30-40			6	4
-145	BG with chlorite	30				4
-146	BG to DG with chlorite. Partly foliated	40				3
-147	GG to BG Fin silt/clay on 147,6m	30			6	8
-148	BG	30			15	6
-149	BG with foliation	40				1
-150	BG	40				4
-151	BG	40				7
-152	BG Surface porosity	40				2
-153	BG	50-60				5
-154	GG to BG Surface porosity	30			18	3
-155	BG Surface porosity	30				2

Meter depth	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency
-156	BG	40				2
-157	BG with chlorite	40				3
-158	BG with PEG	40				2
-159	BG	50				4
-160	BG with foliation Surface porosity	50				4
-161	BG with chlorite. Surface porosity.	40				5
-162	GG to BG with surface porosity. Vertical fractures.	40				6
-163	DG. Crushed core, drilling induced	40			10	4
-164	DG	40				3
-165	BG	50				3
-166	BG	50				4
-167	BG	50				4
-168	BG to DG with Q-veins. Polished micasurfaces	30-40				7
-169	BG to DG with Q-veins.	30-40				9
-170	BG with Q/epidot vertically through	40				6
-171	BG	40				4
-172	BG with chlorite.	40-50				4
-173	BG with chlorite.	40-50			5	6
-174	BG with chlorite	40			3	3
-175	BG with chlorite.	40			8	7
-176	BG with chlorite	50			10	4
-177	BG with chlorite	50-60				1
-178	BG with folded Q-veins	40				3
-179	GG/BG	30/50			5	3
-180	GG	20			100	0
-181	BG with chlorite	40-50			54	3
-182	Bands (8-20 cm) of GG/BG.					2
-183	Same as above					1
-184	Same as above				32	4

Meter depth	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency
-185	BG with surface porosity. Some GG, Chlorite					6
-186	Same as above					4
-187	Light BG. /Last 5 cm: BG	40/70-80				5
-188	GG. Bands of biotite	20-30				2
-189	BG to GG. Slickensides 189,80m	30				3
-190	BG to GG. Slickensides, chlorite	30				2
-191	BG to GG. Slickensides?	30				4
-192	GG.	20-30				2
-193	GG	20-30				3
-194	GG. Big Q-grains	20-30				3
-195	GG/peg. Slickensides	20				3
-196	GG to BG	10/30-40				4
-197	GG	20-30				5
-198	BG	50				5
-199	BG with chlorite	40				8
-200	BG. Big Q-grains on surface	30-40				2
-201	Peg/GG with biotitebands.	20-30				2

KH-02-Ø 2006 - Upper borehole no. 2 2006

Meter depth	** Effective Fracture frequency	Foliation parallel fractures	Other fractures	Fracture angle	Fracture filling/ nature of fracture plane	RQD	Depth of sample start (m)
0						0	
-1	26	4		25+30		20	
-2	25	6		60+b+F		20	
-3	10	6		30-45+b		82	3,82 m
-4	4			F(40)		85	
-5	4	2		65+F		78	
-6	13	6		F(30)		80	
-7	15	7		F(30)		84	
-8	25	6		60+F(30)		32	8,06
-9	25	5		60+F(30)		33	
-10	25	2		30-60, 80		67	

Meter depth	** Effective Fracture frequency	Foliation parallel fractures	Other fractures	Fracture angle	Fracture filling/ nature of fracture plane	RQD	Depth of sample start (m)
-11	20	5		60+F(25-35)		55	
-12	12	6		60+F(30)		80	
-13	8	5		40-60+F(40)		84	13,8
-14	25	6		50-80+F(30-40)		40	
-15	15	5		55-80+F(30-45)		56	
-16	30	2		60+F(40)		32	
-17	15			45-70+F(30)		65	
-18	10			70+F(30)		44	18,88
-19	24			55+F(30-40)		49	
-20	15			70+F(40)		30	
-21	19			80+F(15-35)		35	
-22	12			40-60+F(25)		74	
-23	14			45-65(+F(30))		65	
-24	11			50+F(30)		47	24,15
-25	15			55		58	
-26	12			55+F(30)		52	
-27	20			F(35)		44	
-28	30			F(25-30)		34	28,75
-29	40			85+F(30)		0	
-30	15			40+F(25)		64	
-31	22			60(b?)+F(30)		37	
-32	22			F(30)		10	
-33	35			F(30)		20	33,82
-34	14			50+F(30)		50	
-35	21			35-50		40	
-36	10			35-55		74	
-37	11			30-45		39	
-38	16			40-55+F(30)		30	38,33
-39	10			50+b?+F(40)		65	

Meter depth	** Effective Fracture frequency	Foliation parallel fractures	Other fractures	Fracture angle	Fracture filling/ nature of fracture plane	RQD	Depth of sample start (m)
-40	7			50+F(40)		69	
-41	7			40-60+F(35)		79	
-42	29			45(b?)+F(40)		38	
-43	13			20,30,50		48	43,78
-44	19			25-30+F(30)		10	
-45	32			30-45		34	
-46	10			10-25+F(20)		40	
-47	9			25		67	
-48	3			10-20		100	
-49	8			35+10(b?)		91	49,09
-50	8			25		33	
-51	28			35+F(25)		36	51,27
-52	6			30		85	
-53	4			b		100	
-54	6			20-45		91	54,16
-55	6			15		90	
-56	3			F(35-40)		100	
-57	6			20-45, F(25)		75	
-58	10			45, F(30)	silty/clayish filling	100	
-59	8			F(15-25)		82	59,1
-60	16			50, 30, 40, F(30-40)		49	
-61	9			20-45+F(30)		63	
-62	10			45+F(35)		82	
-63	5			F(40)		80	
-64	7			F(40)		55	64,13
-65	12			F(25-40)		72	
-66	5			F(35)		87	
-67	3			F(25)		100	
-68	2			25		100	

Meter depth	** Effective Fracture frequency	Foliation parallel fractures	Other fractures	Fracture angle	Fracture filling/ nature of fracture plane	RQD	Depth of sample start (m)
-69	5			F(25)		86	69,21-69,3
-70	1					100	
-71	1			F(25)		100	
-72	0			b		100	
-73	2			30 b?		75	
-74	0			b?		100	74
-75	1			F(30)		100	
-76	0			20, 30, b?		100	
-77	0			b		100	
-78	0			b		100	
-79	0					100	79,14
-80	2			20 b?		90	
-81	6			15, F(30)		80	
-82	5			F(30)		72	
-83	3					100	
-84	6			F(35)		76	84,06
-85	8			F(25-40)		91	
-86	5			F(25,35)		91	
-87	5			F(40)		91	
-88	7			F(40)		93	
-89	4			20, F(30)		100	89,07
-90	5			F(20)		64	
-91	2			40, F(25)		100	
-92	2			F(35)		100	
-93	4			45, F(35)		94	
-94	9			F(35-50)		79	94,25
-95	5			25, F(40)		85	
-96	7			F(20-30)		66	
-97	4			45-55		92	

Meter depth	** Effective Fracture frequency	Foliation parallel fractures	Other fractures	Fracture angle	Fracture filling/ nature of fracture plane	RQD	Depth of sample start (m)
-98	6			25, 65, F(30)		79	
-99	6			15, F(35-45)		87	99,15
-100	3			F(25)		89	
-101	6			35-70		86	
-102	7			40, 55, F(30)		76	
-103	8			F(20-40)		77	
-104	8			F(20)		84	104,89
-105	6			20, F(35)		81	
-106	10			F(15-30)		63	
-107	0			b		100	
-108	2			F(20)		93	
-109	0			b		100	109,94
-110	0			b		100	
-111	2			b		100	
-112	2			15		100	
-113	2			15		100	
-114	8			F(20-40)		82	114,53
-115	4			F(25)		95	
-116	5			F(15-35)		87	
-117	3			F(20-30)		100	
-118	7			F(25-30)		88	
-119	15			F(30)		72	119,08
-120	3			15, F(20, 30)		100	
-121	3			25, F(30)		91	
-122	2			F(15,35)		100	
-123	3			F(15)		85	
-124	3			F(15)		95	124
-125	5			F(15-25)		95	
-126	3			F(30,35)		92	

Meter depth	** Effective Fracture frequency	Foliation parallel fractures	Other fractures	Fracture angle	Fracture filling/ nature of fracture plane	RQD	Depth of sample start (m)
-127	13			F(35)		90	
-128	3			60	sandy fractures	100	
-129	1			b		100	129
-130	4			40		94	
-131	3			F(30)		86	
-132	3			45, F(20)		96	
-133	9			15,25, F(30)	Mica and sandy planes	83	
-134	4			F(20-35)		93	134
-135	3			50, F(30)	Bluegrey sandy fractures	97	
-136	5			F(30)	sandy fractures	100	
-137	9			F(20-30)	sandy fractures	58	
-138	0			10 b?		100	
-139	4			F(50)		95	139
-140	10			F(20-35)		89	
-141	3			F(20,35)		100	
-142	8			F(30)		79	
-143	5			F(25)		90	
-144	4			F(20-30)		100	144,16
-145	7			10, F(25)		78	
-146	3			15, F(30)		96	
-147	8			20-55, F(30)		87	
-148	10			F(30)	sandy fractures	63	
-149	1			F(15)		100	149,23
-150	4			45, F(30)	sandy fractures	100	
-151	18			50, F(20-30)	clay on fractures	70	
-152	9			F(20)		100	
-153	14			60, F(25)	Thin layer of clay on fractures	79	
-154	3			20, 45		82	154,19
-155	2			45		100	

Meter depth	** Effective Fracture frequency	Foliation parallel fractures	Other fractures	Fracture angle	Fracture filling/ nature of fracture plane	RQD	Depth of sample start (m)
-156	2			10, 35 b?		100	
-157	3			50, 15, F(35)		100	
-158	2			10, 20		100	
-159	4			20, F(30)		100	159,08
-160	4			F(25)		89	
-161	5			F(30,35)	Sandy surface	91	
-162	6			F(25,35)		80	
-163	8			F(20,25)		84	
-164	3			F(20,25)		93	164
-165	3			15, F(20)		100	
-166	4			F(15)		100	
-167	4			20, F(30,35)		100	
-168	7			F(30-45)		72	
-169	9			F(25,30)	Sandy, clayish surfaces	78	169,28
-170	6			F(20-30)		90	
-171	4			F(25,30)		93	
-172	4			F(20-30)	Sandy fractures. Pyrite surfaces	100	
-173	8			40, 20, random, b?	Clay/drill mud on surface?	80	
-174	3			F(20,25)		92	174,05
-175	10			F(20)	Sandy surfaces	68	
-176	4			F(10-25)		100	
-177	1			F(25)		100	
-178	3			random, b?		91	
-179	3			F(20,25)		90	179
-180	0			None		0	
-181	0			b? random		27	
-182	2			15, 45	Sandy micasurfaces	100	
-183	1			45		100	
-184	4			horizontal		55	184

Meter depth	** Effective Fracture frequency	Foliation parallel fractures	Other fractures	Fracture angle	Fracture filling/ nature of fracture plane	RQD	Depth of sample start (m)
-185	6			20-50, F(25)		86	
-186	4			15, 20, F(25)		82	
-187	5			40, F(20,30)	Fine clay on surface	86	
-188	2			70, F(20)		91	
-189	3			F(20,25)	Fine clay on surface.	96	189
-190	2			F(25,30)		100	
-191	4			65, 45 F(35,40)	Finegrained material on surfaces.	92	
-192	2			F(45)	Sandy surface	91	
-193	3			25, F(30,35)	Crushed mica on surface	91	
-194	3			20, F(30)	clay on surfaces	91	194
-195	3			55, F(40, 45)	Sandy surfaces	92	
-196	4			F(40,45)		91	
-197	5			F(35,40)		91	
-198	5			50, F(20-35)	Sandy surface	96	
-199	8			F(20,30), horizontal	Sandy surface	55	199
-200	2			F(30,35)		100	
-201	2			F(20,40)		95	

KH-02-Ø 2006 - Upper borehole no. 2 2006

Meter depth	Depth of sample end (m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Sample number	Comments
0						
-1						
-2						
-3	3,9 m	Thermal conductivity		Guri Ganerød	24936	
-4						
-5						
-6						
-7						
-8	8,13	Thermal conductivity		Guri Ganerød	24937	
-9						
-10						

Meter depth	Depth of sample end (m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Sample number	Comments
-11						
-12						
-13	13,9	Thermal conductivity		Guri Ganerød	24938	
-14						
-15						
-16						
-17						
-18	18,9	Thermal conductivity		Guri Ganerød	24939	
-19						
-20						
-21						
-22						
-23						
-24	24,52	Thermal conductivity		Guri Ganerød	24940	
-25						
-26						
-27						
-28	28,82	Thermal conductivity		Guri Ganerød	24941	
-29						
-30						
-31						
-32						***1**
-33	33,88	Thermal conductivity		Guri Ganerød	24942	
-34						
-35						
-36						
-37						
-38	38,39	Thermal conductivity		Guri Ganerød	24943	
-39						

Meter depth	Depth of sample end (m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Sample number	Comments
-40						
-41						
-42						Sleppesone avdekka frå boringa. Holrom.
-43	43,85	Thermal conductivity		Guri Ganerød	24944	
-44						Veldig lettoppsprekkelig ved kjerneinspeksjon
-45						
-46						
-47						
-48						
-49	49,18	Thermal conductivity		Guri Ganerød	24945	
-50						
-51	51,33	XRD, Thin scedtion	NGU	Guri Ganerød	24934, 24935	
-52						
-53						
-54	54,24	Thermal conductivity		Guri Ganerød	24946	
-55						
-56						
-57						
-58						
-59	59,25	Thermal conductivity		Guri Ganerød	24947	
-60						
-61						
-62						
-63						
-64	64,25	Thermal conductivity		Guri Ganerød	24948	
-65						
-66						
-67						
-68						

Meter depth	Depth of sample end (m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Sample number	Comments
-69		Thermal conductivity		Guri Ganerød	24949	
-70						
-71						
-72						
-73						
-74	74,07	Thermal conductivity		Guri Ganerød	24950	
-75						
-76						
-77						
-78						
-79	79,21	Thermal conductivity		Guri Ganerød	47251	
-80						
-81						
-82						
-83						
-84	84,13	Thermal conductivity		Guri Ganerød	47252	
-85						
-86						
-87						
-88						
-89	89,14	Thermal conductivity		Guri Ganerød	47253	
-90						
-91						
-92						
-93						
-94	94,32	Thermal conductivity		Guri Ganerød	47254	
-95						
-96						
-97						

Meter depth	Depth of sample end (m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Sample number	Comments
-98						
-99	99,25	Thermal conductivity		Guri Ganerød	47255	
-100						
-101						
-102						
-103						
-104	104,97	Thermal conductivity		Guri Ganerød	47256	
-105						
-106						
-107						
-108						
-109	110	Thermal conductivity		Guri Ganerød	47257	
-110						
-111						
-112						
-113						
-114	114,59	Thermal conductivity		Guri Ganerød	47258	
-115						
-116						
-117						
-118						
-119	119,16	Thermal conductivity		Guri Ganerød	47259	
-120						
-121						
-122						
-123						
-124	124,08	Thermal conductivity		Guri Ganerød	47260	
-125						
-126						

Meter depth	Depth of sample end (m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Sample number	Comments
-127						*5
-128						
-129	129,07	Thermal conductivity		Guri Ganerød	47261	
-130						
-131						
-132						
-133						
-134	134,14	Thermal conductivity		Guri Ganerød	47262	
-135						
-136						
-137						
-138						
-139	139,1	Thermal conductivity		Guri Ganerød	47263	
-140						
-141						
-142						
-143						
-144	144,23	Thermal conductivity		Guri Ganerød	47264	
-145						
-146						
-147						
-148						
-149	149,29	Thermal conductivity		Guri Ganerød	47265	
-150						
-151						
-152						
-153						
-154	154,25	Thermal conductivity		Guri Ganerød	47266	
-155						

Meter depth	Depth of sample end (m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Sample number	Comments
-156						
-157						
-158						
-159	159,15	Thermal conductivity		Guri Ganerød	47267	
-160						
-161						
-162						
-163						
-164	164,08	Thermal conductivity		Guri Ganerød	47268	
-165						
-166						
-167						
-168						
-169	169,34	Thermal conductivity		Guri Ganerød	47269	
-170						
-171						
-172						
-173						
-174	174,15	Thermal conductivity		Guri Ganerød	47270	
-175						
-176						Crushed zones due to hammering on
-177						core when loosening from pipe
-178						178.5 m: crushed during drilling
-179	179,08	Thermal conductivity		Guri Ganerød	47271	
-180						EFF FF: 40
-181						181.6 m: Crushed during drilling. Eff FF: 20
-182						
-183						
-184	184,06	Thermal conductivity		Guri Ganerød	47272	184.7 Crushed during drilling. Eff FF: 18

Meter depth	Depth of sample end (m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Sample number	Comments
-185						
-186						
-187						187.7 m: Crushed during drilling
-188						
-189	189,11	Thermal conductivity		Guri Ganerød	47273	
-190						
-191						
-192						
-193						
-194	194,08	Thermal conductivity		Guri Ganerød	47274	
-195						
-196						
-197						
-198						
-199	199,07	Thermal conductivity		Guri Ganerød	47275	
-200						
-201						

BG = Biotittic gneiss
GG = granittic gneiss
PEG = pegmatite
Q= quartz
f=feldspar
";" = and
*The fracture frequency without crushed rock
Fractures that are obviously made by the drilling process are not included.
This will (probably) give a higher fracture frequency than the background fracturing with at least 20 %.
For crushed rock, it is hard to estimate the amount of F-parallel fractures
**Fracture frequency including crushed rock. For 1 m crushed rock--> FF = 50. 1 m breccia-->FF= 70. For 1 m clay--> FF = 90
The bedrock is very heterogenous and drawing the boundary between the different types is difficult.

The content of mafic minerals is given by ca %, also indicating the changes in the bedrock.
Where several bedrock types are indicated, there is a frequent change in bedrock, indicating it beenig even more heterogenous.
BB/GG= rock change within the 1 m interval
BB to GG= rock that is a mix of the two categories

KH-03-M 2006 - Middle borehole no. 3 2006

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency	** Effective Fracture frequency	Foliation parallel fractures	Other fractures
0				100					
-1	GG	10		42	12	4	15	0	
-2	BG to GG	40				5	5		
-3	GG	30			10	7	15	1	
-4	GG to BG	40				9	9	5	
-5	GG	20				4	4	4	
-6	GG	20			5	7	15	6	
-7	BG	40			14	16	22	9	
-8	BG	50			18	15	21	10	
-9	BG	50			52	7	21	7	
-10	GG/BG	20				10	10	5	
-11	BG/GG	40			10	7	9	9	

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency	** Effective Fracture frequency	Foliation parallel fractures	Other fractures
-12	GG	30			5	7	7	0	
-13	GG	30			16	7	11	6	
-14	GG to BG	30				7	7	5	
-15	BG	60				12	15	6	
-16	GG/BG	30				5	5	2	
-17	GG to BG	40			15	6	15	3	
-18	BG/GG	30				2	2	1	
-19	GG/BG	40			3	7	7	4	
-20	GG	5			25	7	16		
-21	GG	10			4	3	6		
-22	GG/BG	50				9	9		
-23	GG/BG	50			6	17	21	12	
-24	BG	60				21	21	16	
-25	BG	60				15	15	15	
-26	BG	60				14	14	12	
-27	BG	60				14	14	9	
-28	BG	60			15	13	23	11	
-29	BG to GG	30				8	15	8	
-30	GG	10				6	6	3	
-31	GG	10				7	7	7	
-32	GG	20				5	5	5	
-33	GG	10		75		2	2	2	
-34	GG to BG/BG	78-80			32	9	50	20	
-35	BG/GG	30				8	8	6	
-36	GG with B-bands	20				9	9	6	
-37	GG to DG	40				9	9	2	
-38	GG with chlorite	30				10	10	2	
-39	GG with chlorite	30				7	7	2	
-40	GG with chlorite	30				6	6	4	
-41	GG with B-bands	40				6	6	3	
-42	BG	40				12	12	11	
-43	GG to BG	50				10	10	9	

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency	** Effective Fracture frequency	Foliation parallel fractures	Other fractures
-44	GG/BG	50				12	12	12	
-45	BG to GG	40				12	12	11	
-46	GG to DG	40				6	6	2	
-47	GG	40				5	5	3	
-48	GG with B-bands	40				7	7	6	
-49	BG/GG	50				5	5	4	
-50	GG	20				1	1		
-51	GG	20				4	4	1	
-52	GG	30				3	3	1	
-53	GG	20				5	5	2	
-54	GG/BG	40				5	5		
-55	BG	60				12	12	5	
-56	BG to GG	40-50				5	5	3	
-57	GG with B-bands	40-51				9	9	5	
-58	BG to GG	40-52				6	6	5	
-59	GG to BG	40-53				6	6	5	
-60	BG with B-bands	40-54				6	6	4	
-61	BG with B-bands	40-55				5	5	4	
-62	BG with B-bands	40-56				7	7	7	
-63	GG	30				11	11	10	
-64	GG	30				7	7	7	
-65	GG to BG	40				5	5	3	
-66	GG	30				9	9	7	
-67	GG to BG	40				6	6	3	
-68	GG	30				12	12	10	
-69	GG	30				7	7	4	
-70	GG/BG	20				4	4	4	
-71	BG	50				4	4	4	

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency	** Effective Fracture frequency	Foliation parallel fractures	Other fractures
-72	GG to BG	40-50				5	5	5	
-73	BG with Q-bands	50				11	11	8	
-74	GG/BG	40-50			3	14	17	11	
-75	GG	40				11	11	6	
-76	GG to BG	60				3	3	2	
-77	BG	50			7	5	15	4	
-78	GG	30				16	20	12	
-79	GG	30			18	14	24	7	
-80	GG	40				11	11	7	
-81	GG	40				8	8	8	
-82	GG	40				8	8	6	
-83	GG with B-bands	50				12	12	12	
-84	BG/GG	40				14	14	13	
-85	GG	20				10	10	9	
-86	BG to GG	50				6	6	6	
-87	BG to GG	50				12	12	12	
-88	GG/BG	40				14	14	6	
-89	BG with chl	70				5	5	4	
-90	BG with chl	70				2	2	1	
-91	BG with chlorite	70				4	4	3	
-92	BG with chlorite	70				7	7	7	
-93	BG with chlorite	70				7	7	6	
-94	GG with B-bands	50				14	14	13	
-95	DG	60				11	11	11	
-96	BG	60				6	6	4	
-97	GG to DG	50				8	8	7	
-98	BG with Q-bands	60				10	10	10	
-99	GG with B-bands	40				5	5	4	
-100	BG	70				8	8	7	
-101	BG	60				6	6	5	

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency	** Effective Fracture frequency	Foliation parallel fractures	Other fractures
-102	BG with Q/f-lenses	50				9	9	6	
-103	BG with Q/f-bands	50				8	8	6	
-104	BG with Q/f-bands	60				8	18	17	
-105	BG with chlorite	60				2	2	1	
-106	BG with chlorite	60				6	6	3	
-107	BG with chlorite	60				4	4	3	
-108	BG with chlorite	60				5	5	3	
-109	BG with chlorite	60				4	4	4	
-110	peg/BG	50				9	9	6	
-111	BG	60				9	9	7	
-112	GG	50				6	6	4	
-113	GG til BG	50				7	7	5	
-114	GG til BG	60				4	4	2	
-115	GG	50				3	3	2	
-116	GG/BG	50				4	4	3	
-117	GG til BG	60				6	6	6	
-118	GG til BG	60				6	6	5	
-119	GG	60				5	5	4	
-120	GG tto BG/peg	40				4	4	2	
-121	peg/BG	20				3	3	1	
-122	BG with chlorite	80				4	4	0	
-123	BG with chlorite	60				4	4	1	
-124	GG	50				1	1	1	
-125	GG to BG	50				3	3	3	
-126	GG	10				1	1	1	
-127	GG	20				2	2	0	
-128	GG	30				2	2	1	
-129	GG	30				3	3	3	
-130	GG to BG	40				3	3	2	
-131	GG	30				5	5	4	

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency	** Effective Fracture frequency	Foliation parallel fractures	Other fractures
-132	GG	30				3	3	1	
-133	GG	40				2	2	2	
-134	GG	40				6	6	2	
-135	GG	50				4	4	4	
-136	GG	40				1	1	0	
-137	GG	40				3	3	3	
-138	GG	40-50				2	2	2	
-139	GG	40-50				4	4	4	
-140	GG	30				2	2	2	
-141	GG	30				1	1	1	
-142	GG to BG	40				3	3	3	
-143	GG to BG	50				3	3	3	
-144	GG to BG	40				3	3	3	
-145	GG/BG	40				2	2	2	
-146	BG with chlorite	60				4	4	4	
-147	GG	15				2	2	2	
-148	GG/BG	20				0	0	0	
-149	BG	40				5	5	5	
-150	GG to BG	30				4	4	2	
-151	BG with peg	40				3	3	2	
-152	BG to GG	50				4	4	1	
-153	GG to BG	30				1	1	1	
-154	GG with chlorite	40				6	6	5	
-155	GG	20				4	4	3	
-156	GG	30				4	4	2	
-157	GG	40				4	4	4	
-158	GG to BG	40				4	4	3	
-159	GG	40				3	3	3	

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency	** Effective Fracture frequency	Foliation parallel fractures	Other fractures
-160	GG	15				3	3	3	
-161	GG	20				4	4	2	
-162	GG	25				2	2	2	
-163	GG	30				3	3	3	
-164	GG to BG	40				4	4	1	
-165	GG	40				2	2	2	
-166	GG	50				4	4	4	
-167	GG/BG with chlorite	60				5	5	2	
-168	BG with chlorite	60				3	3	3	
-169	GG to BG	30				5	5	5	
-170	GG	30				2	2	1	
-171	GG to BG	40				1	1	1	
-172	GG to BG	40				6	6	6	
-173	GG	30				2	2	1	
-174	GG	30				4	4	2	
-175	GG	30				3	3	2	
-176	GG	30				5	5	4	
-177	GG	30				3	3	3	
-178	GG	30				2	2	2	
-179	GG/BG with chlorite	40				2	2	2	
-180	BG with chl/GG	40				3	3	3	
-181	GG to BG	30				1	1	1	
-182	GG to BG	30				4	4	2	
-183	GG to BG	30				2	2	2	
-184	GG	30				3	3	3	
-185	GG to BG	40				6	6	6	
-186	GG/BG with chlorite	40				6	6	6	
-187	GG with B-bands	30				4	4	4	

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency	** Effective Fracture frequency	Foliation parallel fractures	Other fractures
-188	GG	30				2	2	2	
-189	GG	15			5	5	5	3	
-190	BG with chlorite	30			32	5	19	15	
-191	GG	20				2	2	2	
-192	GG	20				2	2	1	
-193	GG	20				2	2	2	
-194	GG	10				2	2	0	
-195	GG	10				1	1	1	
-196	GG	5				1	1	0	
-197	GG/BG	30				2	2	2	
-198	GG to BG	30			5	7	9	7	
-199	GG with B-bands	30				5	5	5	
-200	GG with B-bands	40			14	4	14	4	
-201	GG with B-bands	40				5	5	4	
-202	GG with B-bands	40				4	4	4	

KH-03-M 2006 - Middle borehole no. 3 2006

Depth (m)	Fracture angle	Fracture filling/ nature of fracture plane	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Remaining sample material
0			0					
-1	10;35	weathered fra	50 (25/50)					
-2	20-45	weathered/sa	85					
-3	10--50	weathered fra	76					
-4	F(30), 20-40	weathered cla	82					
-5	F(30)		87					
-6	20; F(30-45)		80					
-7	15-45; F(30-40)	sandy, clayish	22					
-8	20-35; F(25;30)	sandy	21					
-9	15-35; F(20)		26					
-10	25; F(25-35)		73					
-11	5--25		74					

Depth (m)	Fracture angle	Fracture filling/ nature of fracture plane	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Remaining sample material
-12	20-50		82					
-13	5;30 F(20)	sand	64					
-14	20-60; F(25;30)	sandy planes	87					
-15	30-45; F(20;35)	sandy planes	69					
-16	20;35; F(45)	sandy	83					
-17	25; F(45;50)	sandy	78					
-18	60; F(50)		100					
-19	30;45; F(45)	sandy						
-20	35-50		69					
-21	15;45	weathered	91					
-22	5;35	weathered, sa	67					
-23	10;45; F(20-30)	mica on plane	20					
-24	10; F(20-30)	sandy	20					
-25	F(25-35)		28					
-26	20;25; F(30-45)	sandy, mica--	53					
-27	F(35-45)	clayish	32					
-28	40;45; F(35;40)	crushed min,	11					
-29	50; F(40;45)		61					
-30	60;80; F(35;40)		52					
-31	40;50;80; F(30)		64					
-32	F(15;35)	mica on plane	72					
-33	F(30)		64					
-34	F(20-35)	clay on planes	75					
-35	20;30;90; F(15-30)	mica on plane	65					
-36	20; F(15-45)	clay at 7; 52; 8	64					
-37	15-40; F(10)	weathered, sa	58					
-38	15-60; F(35)		49					
-39	30-50; F(35)	weathered	65					
-40	45; F(20;40)		86					
-41	30;45; F(20-35)	sandy	84					
-42	60; F(35-40)	sandy,clay at 62 cm						
-43	30; F(30;35)		55					

Depth (m)	Fracture angle	Fracture filling/ nature of fracture plane	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Remaining sample material
-44	F(30;45)		83					
-45	50; F(25-35)		61					
-46	5; 50; F(40)	sandy/clayish	42					
-47	5; F(40;45)	sandy/clayish	98					
-48	50; F(35-45)		95					
-49	30; F(35-45)		85					
-50	irregular		100					
-51	40;50; F(45)		86					
-52	30; F(45)		100					
-53	5;60; F(45)		90					
-54	20-45		71					
-55	10-40; F(20-30)		24					
-56	20;40; F(25;30)		86					
-57	35; irreg; F(25;30)		81					
-58	20; F(25-45)		78					
-59	F(25;35)		88					
-60	F(30;35)		90					
-61	30; F(35)		78					
-62	F(30-45)		87					
-63	50; F(35-45)		69					
-64	F(25-45)		96					
-65	20; F(20-30)		81					
-66	50; 80; F(25-30)		80					
-67	20; 50; F(30;40)		95					
-68	5; 50; F(35-45)		64					
-69	5; 50; F(25;30)		76					
-70	F(30-40)		95					
-71	80; F(30;35)		90					

Depth (m)	Fracture angle	Fracture filling/ nature of fracture plane	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Remaining sample material
-72	F(30;35)	sandy	91					
-73	F(30;35)		56					
-74	30; F(30)		38					
-75	70; F(30)	sandy	70					
-76	F(20;35)		93					
-77	F(15-30)		79					
-78	20; F(30-40)	sand layers, c	30					
-79	20-40; F(30)		27					
-80	10; F(20-30)		39					
-81	30; F(30-40)		47					
-82	F(25-35)		65					
-83	F(30)		45					
-84	F(25-35)		39					
-85	20; F(30)		67					
-86	F(25-45)	mica-->clay	68					
-87	F(25;30)		60					
-88	15-50; F(30;45)		55					
-89	15; F(25-35)		88					
-90	45; F(25)		92					
-91	15; F(25;45)		87					
-92	F(40)		68					
-93	F(30;40)		74					
-94	F(30;40)		20					
-95	F(30;35)	weathered, sa	63					
-96	10-55; F(25-35)		67					
-97	25; F(30;35)		82					
-98	F(25-35)	mica on plane	66					
-99	45; F(30;35)		73					
-100	15; F(35)		69					
-101	80; F(25)		95					

Depth (m)	Fracture angle	Fracture filling/ nature of fracture plane	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Remaining sample material
-102	20-45; F(25;35)		85					
-103	20;40; F(15-45)		80					
-104	50; F(30-40)	sandy	67					
-105	35; F(45)		100					
-106	10-80; F(35;45)		77					
-107	irreg, F(25;35)		94					
-108	60; F(35;45)		89					
-109	50; F(25;45)		98					
-110	10;60; F(10-35)		67					
-111	30;80; F(30-55)		50					
-112	50;60; F(25-60)		81					
-113	10;15; F(25-60)		70					
-114	15; F(25;35)		100					
-115	60; F(25)		100					
-116	5; F(25;45)		91					
-117	F(45)		77					
-118	15; F(40;45)		95					
-119	5; F(45;50)	sandy	77					
-120	irreg.; 30; F(40;50)		92					
-121	20;35; F(25)		91					
-122	10--60	sandy, pyritic	93					
-123	15-30; F(30)		91					
-124	F(25)		100					
-125	F(20;25)	clayparticles	95					
-126	F(30)		100					
-127	10; F(30)		100					
-128	5; F(35)		100					
-129	F(30;35)		93					
-130	15; F(30;40)	calcite	100					
-131	15; F(20-30)	calcite	91					

Depth (m)	Fracture angle	Fracture filling/ nature of fracture plane	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Remaining sample material
-132	10;55; F(40)	calcite	100					
-133	F(30;40)	calcite	100					
-134	10-25; F(20;30)	sandy, calcite	84					
-135	F(15-35)	calcite	91					
-136	45	calcite	91					
-137	F(25;30)		91					
-138	F(30;35)	calcite	92					
-139	F(30;35)	calcite	100					
-140	F(30;35)		92					
-141	F(35)		94					
-142	20; F(35;45)	clayish	100					
-143	F(30)	calcite	100					
-144	F(25;30)		87					
-145	F(20;25)		100					
-146	F(15-30)		71					
-147	F(25;45)		96					
-148			100					
-149	F(10-35)	calcite	92					
-150	50; F(20;35)		91					
-151	45; F(20)		89					
-152	10-45; F(15)		92					
-153	F(30 irregular)		100					
-154	45; F(15-25)		65					
-155	5; F(25;35)		89					
-156	55; F(45)		91					
-157	F(35)		95					
-158	5; F(35-45)		83					
-159	F(30)		90					

Depth (m)	Fracture angle	Fracture filling/ nature of fracture plane	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Remaining sample material
-160	F(40)		100					
-161	15;20; F(25;30)		89					
-162	F(30)	calcite	100					
-163	F(25;30)		100					
-164	15; F(45)	calcite	89					
-165	F(15;35)	calcite	100					
-166	F(35)	calcite	87					
-167	5-55; F(35)	clay minerals,	89					
-168	F(15-35)		100					
-169	F(25-35)		97					
-170	40; F(35)	sandy, irregula	91					
-171	F(30)	calcite	100					
-172	F(30;35)		92					
-173	45; F(30)		91					
-174	50; F(30;45)	weathered at	93					
-175	45; F(15;30)		100					
-176	10; F(30;40)		79					
-177	F(25;55)		100					
-178	F(35;40)	calcite	96					
-179	F(10)		100					
-180	F(10;30)		100					
-181	F(30)		100					
-182	20;30; F(20)		94					
-183	F(30;40)		100					
-184	F(10;25)		99					
-185	F(15;35)	calcite	98					
-186	F(25-45)	calcite	72					
-187	F(15-35)		96					

Depth (m)	Fracture angle	Fracture filling/ nature of fracture plane	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Remaining sample material
-188	F(25;35)		92					
-189	25;55; F(20-30)		94					
-190	F(25-40)		72					
-191	F(25;35)		100					
-192	50; F(45)	clay on planes	94					
-193	F(25)	crushed miner	100					
-194	10		100					
-195	F(30)		100					
-196	50		91					
-197	F(20;25)		93					
-198	10;15; F(30-40)		92					
-199	F(20-30)		96					
-200	25;50; F(30)		84					
-201	40; F(20;30)		91					
-202	F(25;30)		92					

KH-03-M 2006 - Middle borehole no. 3 2006

Depth (m)	Comments
0	
-1	
-2	
-3	slickensides
-4	
-5	
-6	
-7	
-8	surface por/voids
-9	
-10	
-11	irregular, sandy fr, surface por

Depth (m)	Comments
-12	
-13	
-14	surface porosity
-15	
-16	
-17	very high surface por, slickensides
-18	
-19	
-20	
-21	
-22	surface porosity
-23	
-24	surface por, fractures during inspection
-25	surface porosity
-26	
-27	cemented fracture
-28	
-29	
-30	
-31	
-32	
-33	slickensides
-34	surface por. nb! Clay!
-35	
-36	
-37	
-38	
-39	slickensides
-40	slickensides
-41	
-42	
-43	

Depth (m)	Comments
-44	
-45	
-46	
-47	
-48	
-49	
-50	
-51	surface porosity
-52	surface porosity
-53	
-54	
-55	
-56	
-57	
-58	
-59	
-60	
-61	
-62	
-63	
-64	
-65	
-66	
-67	
-68	
-69	
-70	
-71	

Depth (m)	Comments
-72	
-73	
-74	
-75	
-76	
-77	
-78	
-79	
-80	
-81	
-82	
-83	
-84	
-85	
-86	
-87	
-88	
-89	
-90	
-91	
-92	
-93	
-94	
-95	
-96	Slickensides at 35 cm
-97	Easily fractured during inspection
-98	
-99	Slickensides at 92 cm
-100	
-101	

Depth (m)	Comments
-102	
-103	
-104	
-105	
-106	
-107	
-108	
-109	
-110	slickensides towards end
-111	
-112	
-113	slickensides at 95 cm, folded foliation
-114	
-115	surface por, easily broken during inspect.
-116	
-117	
-118	slickensides at 45 cm
-119	slickensides at 95 cm
-120	
-121	slickensides in pegmatite
-122	
-123	
-124	
-125	
-126	
-127	
-128	
-129	
-130	
-131	

BG = Biotittic gneiss
GG = granittic gneiss
PEG = pegmatite
Q= quartz
f=feldspar
";" = and
*The fracture frequency without crushed rock
Fractures that are obviously made by the drilling process are not included.

This will (probably) give a higher fracture frequency than the background fracturing with at least 20 %.
**Fracture frequency including crushed rock. For 1 m crushed rock--> FF = 50. 1 m breccia-->FF= 70. For 1 m clay--> FF = 90
For crushed rock, it is hard to estimate the amount of F-parallel fractures
The bedrock is very heterogenous and drawing the boundary between the different types is difficult.
The content of mafic minerals is given by ca %, also indicating the changes in the bedrock.
Where several bedrock types are indicated, there is a frequent change in bedrock, indicating it beenig even more heterogenous.
BB/GG= rock change within the 1 m interval
BB to GG= rock that is a mix of the two categories

KH-02-N 2006 - Lower borehole no. 2 2006

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency	** Effective Fracture frequency	Foliation parallel fractures	Other fractures	Fracture angle
0				100						
-1				100						
-2	GG	40		82		1	6	0		irregular
-3	GG with B-bands	50				10	10	2		45-60; F(30)
-4	GG	20			9	8	8	4		50; F(25-40)
-5	GG	30				15	15	7		30-60; F(35)
-6	GG	40				13	13	13		F(10-35)
-7	GG	40			8	7	12	5		10-55, irreg; F(35)
-8	GG with B-bands	60			37	7	27	10		45-50; F(40)
-9	GG to BG	60			14	17	22	18		50; F(30-40)

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency	** Effective Fracture frequency	Foliation parallel fractures	Other fractures	Fracture angle
-10	BG to GG	50				9	11	7		60; F(25)
-11	GG	50				15	25	15		irreg;45; 90; F(20-45)
-12	GG/BG to GG	60				5	5	4		90; F(15;25)
-13	BG to GG	80				8	8	6		15; F(20;35)
-14	GG with B-bands	30				6	6	6		F(10)
-15	GG with B-bands	30				11	11	9		30; F(5-20)
-16	BG	40			10	17	22	15		irreg; 40; F(15)
-17	BG with chlorite	50			10	23	28	11		5;90; F(15;20)
-18	BG with chlorite	50				22	25	2		25-60; F(15)
-19	BG with chlorite	80				11	11	3		30; 90; F(30)
-20	BG with chlorite	70			31	6	24	10		irreg; 10-60; F(crushed)
-21	GG with chlorite/BG	40			32	12	37	0		irreg; 30; 40; 80
-22	GG with chlorite/BG	40			15	13	23	10		30-50; F(30;40)
-23	GG with chlorite/BG	40			3	8	10	4		10-50; F(40)
-24	GG with chlorite	50				6	6	3		30-60; F(25;30)
-25	GG with chlorite	60				8	8	5		30; 45; F(10-25)
-26	BG with chlorite/GG	30				3	3	2		45; F(35)
-27	GG with B- and chl-bands	10			10	15	19	14		35-40; F(30)
-28	GG	25			5	13	15	12		40;80 F(30)
-29	GG	10				10	10	4		50; 60; F(10-25)
-30	GG with B-bands	30				4	4	3		20; F(40;45)
-31	GG	20				4	4	4		F(30)
-32	GG	20				6	6	2		25-45; F(30)
-33	GG/BG	60				6	6	6		F(25;35)
-34	GG with B-bands	40-50				6	6	6		F(25-40)
-35	GG	30				10	10	10		F(30;35)
-36	GG	40				7	7	4		40; 80; F(20-30)
-37	GG	30				5	5	5		F(20-35)
-38	GG/BG	60				6	6	6		F(20-35)

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency	** Effective Fracture frequency	Foliation parallel fractures	Other fractures	Fracture angle
-39	GG with B-bands	50				10	10	7		20-60; F(35;40)
-40	BG	60			32	15	45	14		F(35;40)
-41	GG	40				9	9	9		F(25-35)
-42	GG with B-bands	50				12	12	11		20; F(30;35)
-43	GG to BG	50			25	11	24	13		10; 80; F(15;25)
-44	BG to GG	50				14	14	8		5;20; F(20;30)
-45	GG	40				8	8	3		5-35; F(20;25)
-46	GG	40			7	7	12	7		50; F(20-40)
-47	GG	40			7	4	10	8		F(25;35)
-48	BG to GG	80			5	12	12	7		35;45; F(25-45)
-49	BG	50				8	8	8		F(25-35)
-50	BG to GG with chlorite	50				6	6	2		irreg.; 20; F(30)
-51	GG	30				1	1	1		F(45)
-52	GG	30			3	7	10	3		irreg.; 15; F(20)
-53	GG	40				6	6	5		F(20-35)
-54	GG	40				5	5	3		35; F(20;30)
-55	GG with B-bands	50				4	4	3		50; F(30;35)
-56	GG	40			6	6	8	6		F(40)
-57	GG	50				3	3	3		F(20;40)
-58	GG	50				6	6	6		F(30;40)
-59	GG	50				7	7	4		5; irreg:; F(30;45)
-60	BG to GG	70				9	9	9		F(35)
-61	BG to GG	70				6	6	6		F(35-45)
-62	BG (to GG)	70				7	7	6		F(35)
-63	BG to GG	50				6	6	5		irreg., F(40;55)
-64	GG with B-bands	50				10	10	7		45; F(35-45)
-65	GG	40				6	6	6		F(40;45)
-66	GG/BG	60			5	10	15	7		50; F(35)
-67	BG/GG	50				7	7	2		15-45; F(40)

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency	** Effective Fracture frequency	Foliation parallel fractures	Other fractures	Fracture angle
-68	GG	50				7	7	6		45; F(40-50)
-69	GG	50				3	3	1		30;35; F(50)
-70	GG	30				3	3	3		F(45;50)
-71	GG	30				12	12	9		20; F(45)
-72	GG	30				8	8	8		F(25-45)
-73	GG with B-bands	60				5	3	3		irreg., 40; F(50)
-74	GG	50				4	4	3		5; F(40;45)
-75	GG	50				1	1	0		55
-76	GG	50				2	2	0		45
-77	GG	40				2	2	1		40; F(40)
-78	GG with B-bands	50				2	2	0		15;50
-79	GG to BG	60				3	3	3		F(30;35)
-80	GG to BG	60				4	4	1		30;35; F(50)
-81	BG	70				4	4	3		15; F(25)
-82	GG to BG	70				5	5	1		10-35; F(45)
-83	GG with B-bands	50			20	2	20	10?		20;35
-84	GG	30				3	3	3		F(30-40)
-85	GG	30				3	3	3		F(25-40)
-86	GG with B-bands	30				6	6	6		F(15-40)
-87	BG to GG	50				3	3	3		F(10;35)
-88	BG to GG	40				3	3	3		F(30-45)
-89	BG to GG	60				4	4	4		10; F(20;25)
-90	BG to GG	70				3	3	1		20; 50; F(30)
-91	GG	30				3	3	1		25;45; F(35)
-92	BG	60				2	2	2		F(55)
-93	BG	60				4	4	2		45; F(45)
-94	BG	60				6	6	3		45;60; F(40)
-95	BG/GG	50				4	4	4		F(40)
-96	BG/GG	60				6	6	5		60; F(40)

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency	** Effective Fracture frequency	Foliation parallel fractures	Other fractures	Fracture angle
-97	BG	80				2	2	2		F(35)
-98	GG to BG	50			6	7	10	5		irreg., 15; F(30-40)
-99	GG	50				4	4	4		F(30-45)
-100	GG with B-bands	60			2	4	6	6		F(30;35)
-101	BG to GG	50				6	6	6		F(25-40)
-102	BG/GG	50				4	4	4		F(40)
-103	GG with B-bands	60				5	5	3		25;30; F(50;55)
-104	GG	20				4	4	2		irreg.
-105	GG	40				6	6	5		irreg.; F(20-30)
-106	GG	40				5	5	3		irreg.; F(15;20)
-107	GG to BG	60				5	5	4		10; F(15-40)
-108	GG to BG with B-bands	70				8	8	5		irreg.; F(40)
-109	BG	70				6	6	5		25; F(35;40)
-110	BG/GG	60				6	6	5		25; F(35;45)
-111	BG	60				5	5	3		45;50; F(20-35)
-112	BG to GG with chlorite	40				8	8	1		15-40; F(30)
-113	BG with chlorite	60				3	3	3		F(15;20)
-114	BG	50			10	8	13	5		10--60
-115	BG	70		25	17	9	25	15		F(45)
-116	BG	80				2	2	0		15
-117	GG	60				2	2	2		F
-118	BG to GG with chlorite	80				4	4	1		15-40; F(35)
-119	BG with chlorite	80				4	4	2		20;40; F(30)
-120	BG with chlorite	80				3	3	1		20;35; F(25)
-121	BG/GG	70				3	3	3		50; F(55)
-122	BG	50				3	3	2		35; F(35)
-123	BG	70				3	3	2		30; F(40;45)
-124	GG to BG	50			7	4	6	0		55
-125	BG	90			28	3	20	15		10; F(30)

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency	** Effective Fracture frequency	Foliation parallel fractures	Other fractures	Fracture angle
-126	BG/GG	50				6	6	2		10-55; F(45)
-127	BG to GG	50				3	3	3		F(25;40)
-128	BG to GG	50				1	1	1		F(40)
-129	BG	70				2	2	0		50
-130	BG/GG	40				5	5	3		70; F(30;35)
-131	BG	60				2	2	1		irreg.; F(35)
-132	BG/GG	60				2	2	2		F(30;40)
-133	GG	10				4	4	2		15; 80; F(30;35)
-134	GG to BG	20				3	3	1		5; F(30)
-135	GG to BG	20				5	5	0		15--30
-136	GG to BG	20			5	6	8	3		10-50; F(20;25)
-137	GG to BG	30				1	1	1		F(20)
-138	BG	40				2	2	2		F(15)
-139	BG with peg	40				6	6	4		10; F(30;35)
-140	GG/BG	50				6	6	5		20; F(25-45)
-141	BG	50				3	3	3		F(25-45)
-142	GG to BG	30			22	4	4	15		5; F(25)
-143	GG with B-bands	20				2	2	1		45; F(25)
-144	Folded GG with B-bands	20				1	1	0		20
-145	Folded GG with B-bands	20				3	3	1		10; F(25)
-146	Folded GG with B-bands	20				2	2	2		F(30;35)
-147	BG	60				5	5	2		15-25; F(25;35)
-148	BG with chlorite	70				3	3	1		15; F(25)
-149	BG	80				2	2	0		15;65
-150	BG with chlorite	80				2	2	0		15;50
-151	BG with chlorite	70				6	6	1		irreg.; 5-20; F(35)
-152	BG	70				4	4	0		10--20
-153	BG	80				3	3	0		5--55
-154	BG	70				7	7	3		30-55; F(25)

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency	** Effective Fracture frequency	Foliation parallel fractures	Other fractures	Fracture angle
-155	BG	60				3	3	0		10--25
-156	BG/GG	60				2	2	1		40; F(55)
-157	BG	70				1	1	1		F(40)
-158	BG	60				2	2	1		20; F(45)
-159	BG	50				2	2	1		25; F(45)
-160	BG to GG	40			19	2	12	10		F(20;45)
-161	BG	50				2	2	0		20--35
-162	BG	60				4	4	1		30-50; F(45)
-163	BG	60				6	6	3		25-35; F(30-55)
-164	BG	50				3	3	2		45; F(45)
-165	BG	50				3	3	2		45; F(30;45)
-166	BG	60			8	4	9	7		45; F(25;65)
-167	BG	70				3	3	0		20-45
-168	BG with chlorite	70				3	3	0		25-50
-169	Folded BG with chlorite	60				3	3	0		30;35
-170	BG with chlorite	70				2	6	0		15-35
-171	BG with chlorite	70				3	3	0		25;45
-172	BG to GG	60				3	3	0		20-50
-173	BG	70				4	4	0		10;50
-174	BG with chlorite	70				1	1	0		45
-175	BG with chlorite	60				3	3	1		40;55; F(35)
-176	BG to GG	50			6	3	7	6		35; F(30;35)
-177	BG to GG	60				4	4	3		40; F(25-35)
-178	BG to GG	50				3	3	1		25; F(40)
-179	BG	70				5	5	1		irreg.; 10;20; F(20)
-180	BG	70				3	3	1		15; F(20;30)
-181	BG	80				1	1	0		20
-182	BG with chlorite	60				4	4	1		5--15; F(30)
-183	BG with chlorite	60				3	3	1		10;20; F(30)

Depth (m)	Bedrock type	Ca % content of mafic minerals (biotite)	Zones	Core loss [cm]	Crushed rock [cm]	*Fracture frequency	** Effective Fracture frequency	Foliation parallel fractures	Other fractures	Fracture angle
-184	BG with chlorite	60				3	3	1		15;20; F(35)
-185	BG with chlorite	60				3	3	1		15-25; F(15)
-186	BG with chlorite	60				3	3	1		15;20; F(20)
-187	BG with chlorite	70			3	2	5	2		20
-188	BG to GG	40				2	2	0		10;25
-189	GG to BG	60				2	2	0		15
-190	BG	50				2	2	0		20;25
-191	BG	50				3	3	2		10; F(25)
-192	GG to BG	40				0	0	0		0
-193	BG	50				2	2	0		15;20
-194	GG to BG	40				2	2	0		30;35
-195	BG with chlorite	70				3	3	0		30-55
-196		5				2	2	1		45; F(15)
-197		5				1	1	1		F(25)
-198										

KH-02-N 2006 - Lower borehole no. 2 2006

Depth (m)	Fracture filling/ nature of fracture plane	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Remaining sample material
0							
-1							
-2		80					
-3	oxidized	58					
-4		76					
-5	5 m, oxidized	48					
-6		37					
-7	oxidized, sandy	91					
-8	clay on crushed rock planes	26					
-9	clay, oxydized, sandy	25					

Depth (m)	Fracture filling/ nature of fracture plane	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Remaining sample material
-10	weathered at 90 cm	57					
-11		15					
-12	60 cm:crushed minerals, 80 cm: weathered	71					
-13		57					
-14	clay, weathered	90					
-15	clay at 93 cm	86					
-16		53					
-17	clay at 30-40 cm	15					
-18	52-83 cm: clay on fractures	15					
-19	clay at 85 and 90 cm	33					
-20	clay at 5 cm	30					
-21		0	21-21,4	Thin section	NGU	Guri V. Ganerød	Maybe
-22	clay at 86 cm	22					
-23	clay at 82 cm	80	23,8	XRD	NGU	Guri V. Ganerød	No
-24		90					
-25		23					
-26		92					
-27		54					
-28		27					
-29		76					
-30	clay at 93 cm	84					
-31		93					
-32	sand at 87 cm	77					
-33		82					
-34		91					
-35		62					
-36	clay at 72-88 m	70					
-37		83					
-38		86					

Depth (m)	Fracture filling/ nature of fracture plane	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Remaining sample material
-39		62					
-40	sandy	0					
-41		62					
-42	clay at 62 cm	40	42,5	XRD	NGU	Guri V. Ganerød	No
-43		25					
-44	clay at 78 cm and 82 cm	56					
-45		84					
-46		72					
-47		88					
-48	weathered at 26 cm	67					
-49		56					
-50		87					
-51		100					
-52		81					
-53	oxidized at 30 cm	72					
-54		86					
-55		87					
-56		73					
-57		100					
-58	mineral grains on surfaces	89					
-59		90					
-60	oxidized, crushed minerals	74					
-61		78					
-62		93					
-63		82					
-64	oxidized and weathered at 70 cm	90					
-65		81					
-66		82					
-67	crushed mica at 20 cm, sandy at 59 cm	94					

Depth (m)	Fracture filling/ nature of fracture plane	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Remaining sample material
-68		75					
-69		97					
-70	calcite at 45 cm	94					
-71		57					
-72		70					
-73		80					
-74		93					
-75		100					
-76		100					
-77		93					
-78		100					
-79		92					
-80		87					
-81		92					
-82		88					
-83		100					
-84		100					
-85		92					
-86		78					
-87		97					
-88		92					
-89		97					
-90		91					
-91		89					
-92		100					
-93		91					
-94		77					
-95	sandy at 19 cm	84					
-96	sandy at 70 cm	92					

Depth (m)	Fracture filling/ nature of fracture plane	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Remaining sample material
-97		100					
-98		72					
-99		100					
-100		97					
-101		91					
-102		98					
-103		84					
-104		92	50 cm			ETH	
-105		92					
-106		90					
-107	pyrite	73					
-108		90					
-109		85					
-110		91					
-111	sandy	86					
-112		61					
-113		100					
-114	sandy	58					
-115		30					
-116	clay minerals at 58 cm	100					
-117		95	85 cm			H. Willenberg	
-118		86					
-119		100					
-120		100					
-121		98					
-122		92					
-123		89					
-124	re-opened previously cemented fractures	76					
-125		68					

Depth (m)	Fracture filling/ nature of fracture plane	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Remaining sample material
-126		82					
-127		99					
-128	calcite, clay minerals	92					
-129	silty at 85 cm	100					
-130		89					
-131	calcite at 28 cm	94					
-132		92					
-133		88					
-134		88					
-135		95					
-136		78					
-137		100					
-138	sandy at 83 cm	95					
-139	sandy at 6 and 15 cm	72					
-140		78					
-141		90					
-142	clay minerals at 21 cm	58					
-143		100					
-144		100					
-145		97					
-146		100					
-147		93					
-148		100					
-149		95					
-150	clay, calcite at 90 cm	91					
-151		92					
-152		91					
-153	re-opened previously cemented fractures	100					
-154		77					

Depth (m)	Fracture filling/ nature of fracture plane	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Remaining sample material
-155	calcite, clay minerals	93					
-156		100					
-157		100					
-158		100					
-159	clay minerals	100					
-160	calcite	80					
-161		100					
-162	weathered at 22 cm, calcite at 66 cm	100					
-163	sandy at 8 and 30 cm, calcite at 58 cm	75					
-164		93					
-165		94					
-166	calcite at 52 cm	83					
-167	calcite at 53 cm	91					
-168	re-opened previously cemented fracture at 83	100					
-169	calcite, feldspar (?) on planes	100					
-170	calcite	90					
-171	sandy	100					
-172		100					
-173		91					
-174	calcite	100					
-175		100					
-176		73					
-177	calcite	92					
-178	weathered at 28 cm	97					
-179		85					
-180	weathered at 20 cm, clay minerals at 60 cm	100					
-181	calcite on entire plane	100					
-182		92					
-183		90					

Depth (m)	Fracture filling/ nature of fracture plane	RQD	Sample (length of sample, m)	Type of analysis	Where is analysis perforwith	Who is in charge of sample	Remaining sample material
-184		100					
-185		94					
-186		100					
-187	sandy crushed material	86					
-188		100					
-189		100					
-190		100					
-191	weathered/oxidized at 39 cm, clay min at 68 c	100					
-192		100					
-193		100					
-194	silty, calcite	100					
-195	calcite	89					
-196	silty	93					
-197		92					
-198							

KH-02-N 2006 - Lower borehole no. 2 2006

Depth (m)	Comments
0	
-1	
-2	
-3	
-4	
-5	slickensides at 8 cm
-6	
-7	
-8	surface porosity
-9	

Depth (m)	Comments
-10	
-11	
-12	
-13	surface porosity
-14	
-15	
-16	
-17	vertical cemented fractures that are reopened
-18	vertical cemented fractures that are reopened
-19	vertical cemented fractures that are reopened
-20	vertical cemented fractures that are reopened
-21	
-22	vertical cemented fractures that are reopened
-23	
-24	
-25	
-26	slickensides at 58 cm
-27	
-28	
-29	
-30	
-31	slickensides at 32 cm
-32	
-33	slickensides at 24 and 42 cm
-34	
-35	slickensides at 80 and 85 cm
-36	
-37	slickensides at 33 m
-38	

Depth (m)	Comments
-39	
-40	crushed mat.developing to clay
-41	slickensides at 75 cm
-42	
-43	
-44	slickensides at 82 cm
-45	
-46	slickensides at 33 cm
-47	
-48	
-49	
-50	slickensides at 30 cm
-51	
-52	
-53	slickensides at 30 cm
-54	
-55	surface porosity
-56	
-57	
-58	
-59	slickensides at 23 cm
-60	
-61	slickensides at 51 cm
-62	
-63	
-64	
-65	slickensides at 55 cm
-66	crushed B-rich
-67	

Depth (m)	Comments
-68	
-69	
-70	
-71	
-72	
-73	
-74	
-75	
-76	
-77	
-78	
-79	
-80	
-81	
-82	
-83	is this induced by drilling process??
-84	
-85	
-86	
-87	
-88	
-89	
-90	slickensides at 46 cm and 72 cm
-91	
-92	
-93	
-94	
-95	
-96	

Depth (m)	Comments
-97	
-98	
-99	
-100	
-101	
-102	
-103	
-104	
-105	slickensides at 88 cm
-106	
-107	
-108	35-42 cm: Very dark BG
-109	slickensides at 31 cm
-110	
-111	
-112	
-113	
-114	
-115	
-116	
-117	slickensides at 5 cm
-118	slickensides at 92 cm
-119	
-120	
-121	
-122	slickensides at 45 cm
-123	
-124	
-125	

Depth (m)	Comments
-126	
-127	
-128	
-129	
-130	
-131	
-132	
-133	slickensides at 22 cm
-134	
-135	
-136	
-137	
-138	
-139	
-140	
-141	
-142	slickensides at 72 cm
-143	
-144	
-145	
-146	
-147	
-148	
-149	
-150	
-151	
-152	
-153	slickensides at 38 cm and 88 cm
-154	slickensides at 35 cm

Depth (m)	Comments
-155	
-156	
-157	
-158	
-159	
-160	
-161	
-162	
-163	
-164	
-165	
-166	
-167	slickensides at 53 cm and 85 cm
-168	
-169	
-170	
-171	slickensides at 75 cm
-172	
-173	
-174	
-175	
-176	
-177	
-178	
-179	
-180	
-181	
-182	
-183	

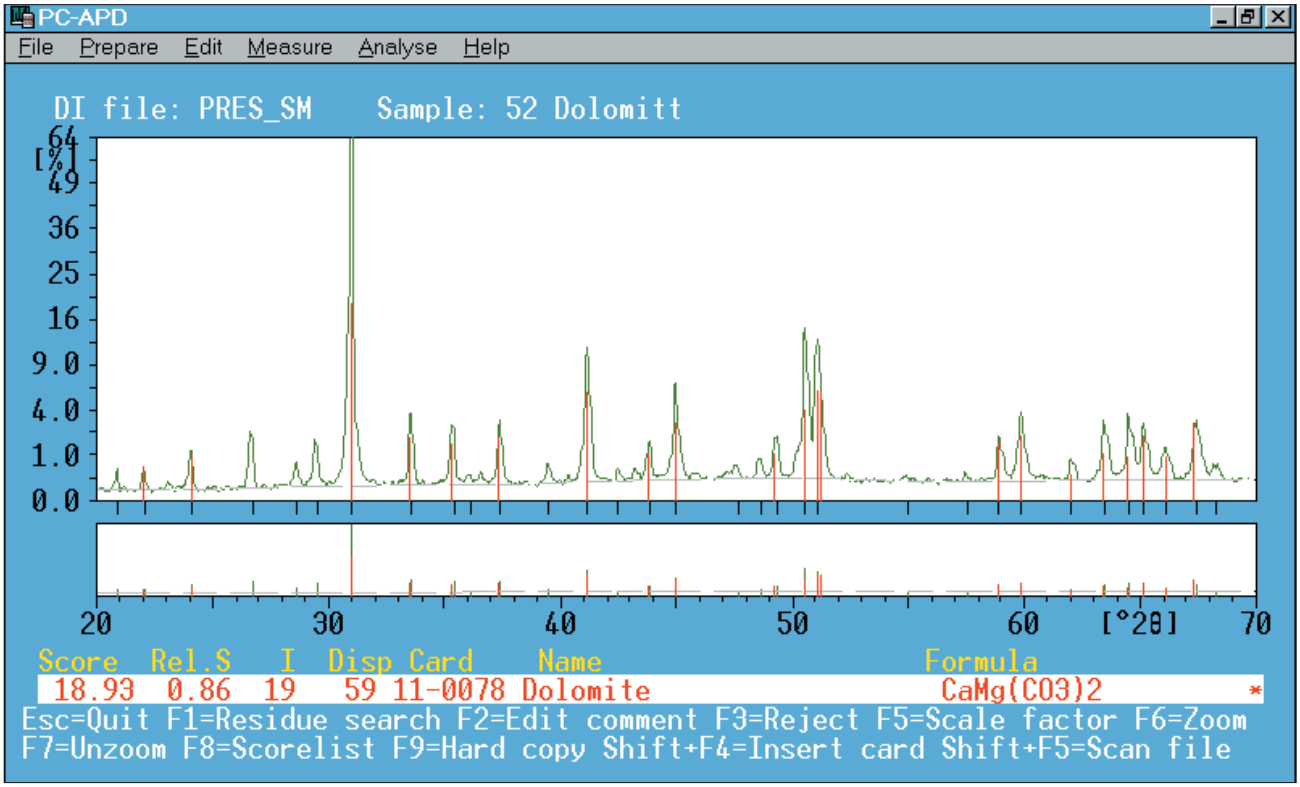
Depth (m)	Comments
-184	
-185	
-186	
-187	
-188	
-189	
-190	
-191	
-192	
-193	
-194	
-195	
-196	
-197	
-198	

XRD-analyser

Ved NGU anvendes røntgendiffraksjon (XRD) til identifikasjon av mineraler. Dette er en viktig del av studier tilknyttet utvikling av mineralressurser, spesielt industrimineraler, samt generell geologisk kartlegging.

Prinsipp

Prinsippet er basert på at refleksjon av en monokromatisk røntgenstråle som sendes inn på en krystallflate er avhengig av krystallens gitterstruktur. I praksis sendes strålen på prøven med varierende innfallsvinkel, og reflekser registreres ved korresponderende utfallsvinkler. Vinklene korresponderer med gitteravstander relatert til ulike plansett og registreres i form av et diffraktogram. Således vil et hvert mineral gi opphav til et helt unikt mønster, som et fingeravtrykk for dette mineralet. Identifisering gjøres ved at diffraktogrammene for ukjente prøver sammenlignes med mønstre for kjente mineraler (database).



Instrumentering

Til XRD analyse benytter NGU-Lab et moderne (1994) Philips X`Pert MPD instrument som er helt PC-styrt bl.a. med programmerbar optikk og programvare-basert identifisering.

Philips X'Pert MPD

Detalj av detektorsystem med detektor, monokromator og programmerbar opptikk.

XRD-analyser ved NGU

I NGU-Labs virksomhet inngår metoder for kvalitativ XRD-analyse av klastiske mineraler og leirmineraler:

Identifisering av klastiske mineraler

Prøven pulveriseres og overføres til prøveholder. I tilfelle lite prøvematerale, f.eks. enkeltmineraler, benyttes en spesiell prøveplate som gir minimal bakgrunnsstøy.

Identifisering av leirmineraler

Analyse av bulk/fraksjon (< 63 µm).

Analyse av finfraksjon (f.eks. < 6 µm). Aktuell fraksjon fraskilles ved bruk av sentrifuge eller synking i væskesylinder (Stokes lov), og filtreres over på et keramisk filter før analyse. Glykolbehandling og varmebehandling kan være aktuelt for å skille mellom ulike leirmineraler (eks. svelleire, kaolinitt m.m.).

Semikvantitative analyser

I prinsippet vil arealene under toppene i et diffraktogram være proporsjonale med konsentrasjonen av mineralet som gir opphav til den aktuelle toppen. I praksis kan det ofte være en del effekter som kompliserer en slik kvantifisering, f.eks. linjeoverlapp, matriseeffekter, uegnede referanse-materialer m.m. Således må eventuelle semikvantitative analyser avtales spesielt, avhengig av de aktuelle problemstillinger.

NGU
Norges geologiske undersøkelse

NGU
7491 Trondheim

Telefon: 73 90 40 00
Telefax: 73 92 16 20

Besøksadresse:
Leiv Eirikssons vei 39

E-post: ngu@ngu.no

KONTAKT NGU-Lab:

tlf.: 73 90 40 00
e-post: lab@ngu.no

Karakterisering av mineraler og bergarter

Karakterisering av mineraler og bergarter er en sentral del av virksomheten ved NGU-Lab. Mens den første grovkarakteriseringen av en bergart eller et mineral utføres av geologene i felt og deretter ved bruk av mikroskop, benytter laboratoriene forskjellige analyseteknikker for å:

- gi detaljert informasjon om kjemisk sammensetning av bergarter og mineraler.
- gi informasjon om fysikalske parametre som f.eks. kornstørrelse

Slik informasjon er viktig for bedrifter og private for prospektering og utvikling av mineralressurser, spesielt med hensyn til produksjon av industrimineraler, malm og byggeråstoffer.

Analyseresultatene benyttes bl.a. til å:

- bekrefte identitet av enkelte bergarter eller mineraler
- karakterisere variasjoner i kjemisk sammensetning mellom mineraler/bergarter og innenfor enkelte mineraler/bergarter
- karakterisere mineralene knyttet til mineralforekomster
- vurdere mengdeforhold og mengdeforholdsvariasjoner for et mineral/bergartsprodukt
- vurdere om en bergart/et mineral fra en forekomst oppfyller, eller har potensiale til å oppfylle, kravene til et mineralprodukt
- vurdere bergarter med hensyn til miljømessige krav, f.eks. innhold av skadelige elementer/mineraler.
  I tillegg til kjemisk karakterisering, utfører NGU-Lab måling av mekaniske egenskaper av bergarter som skal benyttes som byggeråstoffer.

Prøvemottak og prøvepreparering:
Ved mottak blir alle prøver gitt et unikt prøvenummer og registrert i en database. Preparantverkstedet utfører saging og produksjon av tynnslip, samt preparering for spesielle teknikker, f.eks. tynnslip eller planslip til LA-ICP-MS eller SEM og preparering av prøver til petrofysiske undersøkelser. Referanseprøver kan leveres tilbake til oppdragsgiver, evt. oversendes til NGUs Geodatasenter på Løkken for lagring. Ved behov for separasjon av enkelte mineraler, f.eks. for aldersdatering eller for å få renere fraksjoner til mineralidentifikasjon, skjer dette ved vårt mineralseparasjonslaboratorium med bl.a. vaskebord, tunge væsker og magnetseparasjon. Bergarter som skal analyseres med XRF, XRD, ICP-AES, ICP-MS m.m. håndteres først av seksjonen for preanalyse kjemi hvor knusing, mølling, sikting og splitting utføres etter dokumenterte prosedyrer. Fra preanalyse kjemi blir prøvene sendt videre til analyselaboratoriene der ytterligere behandling foretas før analyse.

Analyseteknikker

XRF:	Kvantitativ bestemmelse av hoved- og sporelementinnhold. Hovedelementer bestemmes i tabletter fremstilt av prøver smeltet med litiumtetraborat. Sporelementer bestemmes i pressede prøvetabletter.
XRD:	Identifikasjon av leirmineraler og klastiske mineraler. Muligheter for semikvantitative bestemmelser.
ICP-AES:	Kvantitativ bestemmelse av kationer etter oppslutning med syre (f.eks. med 7N HNO_3 ved 120°C i autoklav, eller med HF i mikrobølgovn).
LA-HR-ICP-MS:	ICP-MS laserablasjonanalyse benyttes til kvantitativ bestemmelse av kjemiske elementer og isotoper i faste materialer, f.eks. i tynnslip og prøver smeltet med litiumtetraborat til homogene glasstabletter.
HR-ICP-MS:	Kvantitativ analyse etter oppslutning.
SEM:	Elektronmikroskopi og kvalitative/kvantitative punktanalyser med EDS/WDS i faste materialer (tynnslip eller bergarts-/mineralprøver).
Fysikalske egenskaper:	Kornfordeling m.m. (kan utføres med laserdiffraksjon, tørr- eller våtsikting).
Petrofysiske analyser:	Petrofysiske egenskaper, bl.a. egenvekt, susceptibilitet, Curietemperatur og remanens.
^{40}Ar-^{39}Ar datering:	Geokronologisk laboratorium (aldersdatering).

NGU
Norges geologiske undersøkelse

NGU
7491 Trondheim

Telefon: 73 90 40 00
Telefax: 73 92 16 20

Besøksadresse:
Leiv Eirikssons vei 39

E-post: ngu@ngu.no

KONTAKT NGU-Lab:

tlf.: 73 90 40 00
e-post: lab@ngu.no

Kvalitetssikring
Siden 1994 er NGU-Lab akkreditert av Norsk Akkreditering for Geologisk prøving (P08) og kjemiske analyse (P12) av vann og geologisk materiale under registreringsnr. TEST020.

NORSK AKKREDITERING TEST 020

Geological Survey of Norway
N-7491 Trondheim, Norway
Tel.: 47 73 90 40 00
Telefax 47 73 92 16 20

Oppdragsgiver: RESLAB, Stiklestadveien 1, 7041 Trondheim.
Analysekontrakt: 2005.0315

TC-Report 04/05

Thermal conductivity of 3 limestone samples.

Bjørn Wissing, Kirsti Midttømme og Janusz Koziel

Table 1 shows the results from thermal conductivity measurements on 3 limestone samples, using a transient method.

Table 1. Measured thermal conductivities.

Sample		**Thermal conductivity W/m·K**
1541.65		1.9
1546.30		1.9
1558.25	wet	2.2
	dried	2.0

SAMPLES

The samples are fine-grained limestone. Samples 1541.65 and 1546.30 are shelly, very porous, oil filled, light brown limestones. Sample 1558.25 is fine grained non bedded slightly bedded, light grey coloured limestone.
Thermal conductivity was measured on cores with diameter 37.3 mm and length in the range 19.9 – 20.2 mm. Two thermal conductivity (tc)samples were prepared from the cores and each tc-samples were measured twice.

METHOD

The thermal conductivity was measured using a transient method. A constant heat flow is induced to the top of the sample. The heat mechanism is radiation and the heat source, with a constant temperature of 161ºC ±2K, is placed 4-9 mm above the top surface of the sample. The sample is insulated on all other surfaces. Temperature is measured at the base of the sample. Thermal diffusivity (α) is estimated from the temperature – time plot, and the thermal conductivity (k) is calculated from thermal diffusivity, density (ρ) and specific heat (c_p) of the sample using equation 1:

$$k = \rho c_p \alpha \qquad \text{(eq 1.)}$$

The theory of this method is described in Carslaw & Jaeger (1959) and Middleton (1993).

Quality control and correction due to the sample length is carried out by measurements on the standard material Pyroceram 9606. Two thermal conductivity samples and two calibration samples are measured in one measurement. Reproducibility of repeated measurements with the apparatus on a variety of rock samples is within 10 %.

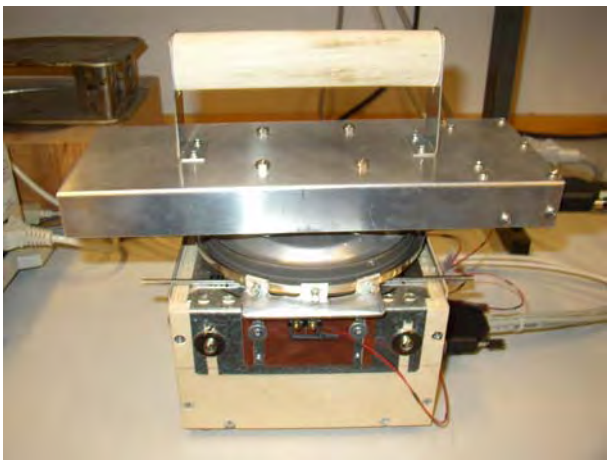


Figure 1a. NGU's apparatus for measurement of thermal conductivity. Sample holder for four samples **Figure 1b**.The heat source on the top of the samples.

THERMAL CONDUCTIVITY MEASUREMENTS

Table 2 (Appendix 1) shows data recorded for the thermal conductivity measurements. Temperature was recorded every second, and the highest value for the slope of the temperature-time plot during a 350 sec interval was used in the calculations. Specific heat of the limestone samples is estimated from the heat flow measured through the calibration samples. Specific heat varies from 1,25 – 1,48 kJ/kg K. Densities were calculated from the volume and weight of the samples.

DISCUSSION

Measured thermal conductivities are in the range 1.9-2.2 W/mK for the limestone samples. The value is in the lower range of thermal conductivity values presented in Blackwell & Steele, 1989 (limestone 2.50 – 3.10 W/m·K). The fine-grained texture and the high porosity of the samples may explain the low thermal conductivity value.
The samples had been stored under room condition before measurement and were therefore not 100 % water saturated. Sample 1558.25 was dried before the second measurement. Lower values of both the specific heat capacity and the thermal conductivity were measured for the dried samples.

REFERENCES.

Blackwell, D.D. & Steele, J. L. 198: Thermal conductivity of Sedimentary Rocks: Measurement and Significance. In Naeser, N. D. & McCulloh, T.H. *Thermal History of Sedimentary Basins. Methods and Case Histories.* Springer-Verlag, 13-36.

Carslaw, H.S & Jaeger, J.C 1959: *Conduction of heat in solids*: Oxford Univ Press. Inc.

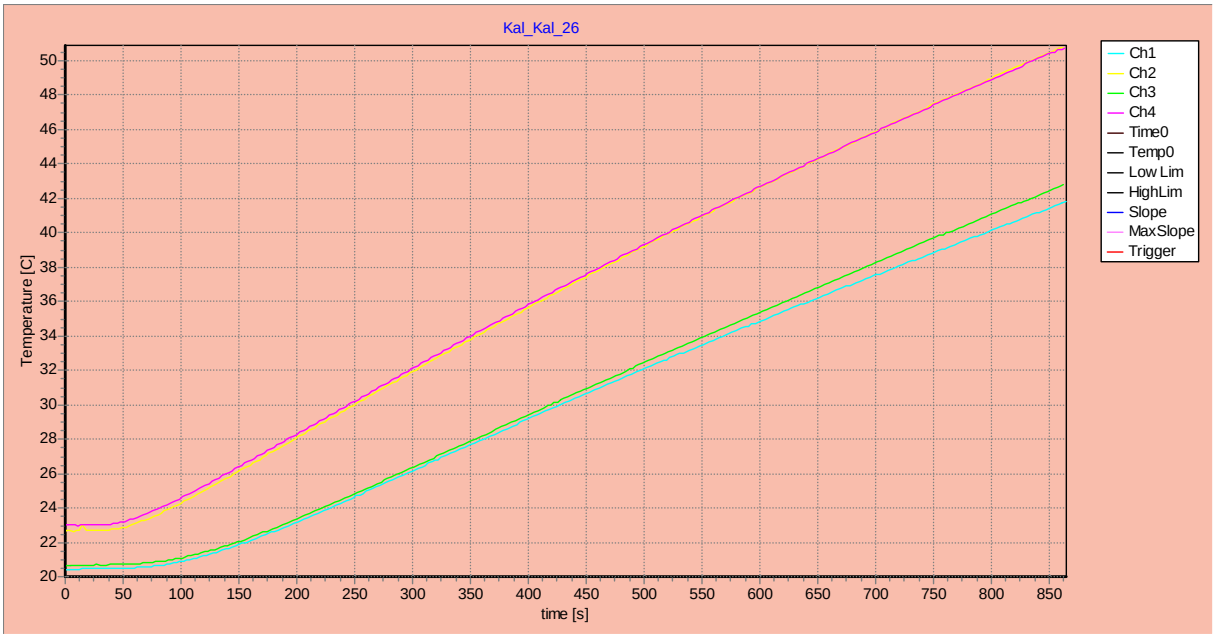
Middleton M.F. 1993: A transient method of measuring the thermal properties of rocks. *Geophysic*, 58, 357-365.

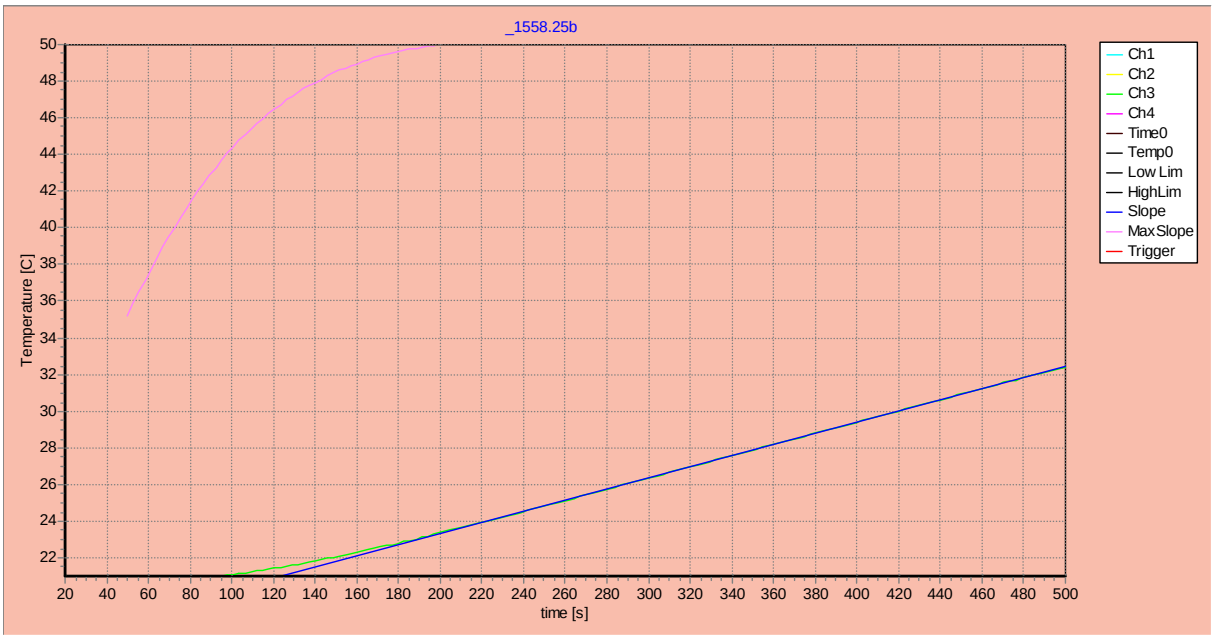
Appendix 1

Table 2

Results of thermal conductivity measurements of 3 core samples,

Sample	Measurement	Position in samplebox	Info	Date	Thickness	Diam.	Est. volume	Weight	Est. density	Specific heat	**Thermal cond.**	Correction factor	**Corr. thermal cond.**	Thermal diff.	Heat flux	Time intercept	Slope
ID				dd.mm.ye	a[mm]	d[mm]	V[cm3]	w[g]	ro[g/cm3]	c[Ws/kg*K]	**k[W/mK]**		**k[W/mK]**	alfa[m^2/s]	F[W/m2]	ti[s]	m[K/s]
Kal_20	1	2			20,78	35		51,36	2,6	870	3,619	1,07764576	3,9	1,60E-06	1810	44,98	0,03852
Kal_20	2	2		19.09.2005	20,78	35		51,36	2,6	870	3,626	1,07556536	3,9	1,60E-06	1820	44,89	0,03872
Kal_20	3	2		19.09.2005	20,78	35		51,36	2,6	870	3,765	1,03585657	3,9	1,66E-06	1853	43,24	0,03942
Kal_20	4	4		19.09.2005	20,78	35		51,36	2,6	870	3,782	1,03120042	3,9	1,67E-06	1851	43,04	0,03937
Kal_21	1	4		19.09.2005	20,99	35		52,23	2,6	870	3,615	1,07883817	3,9	1,60E-06	1807	45,95	0,03806
Kal_21	2	4		19.09.2005	20,99	35		52,23	2,6	870	3,494	1,1161992	3,9	1,55E-06	1854	47,54	0,03906
Kal_21	3	4		19.09.2005	20,99	35		52,23	2,6	870	3,841	1,01536058	3,9	1,70E-06	1872		
Kal_21	4	2		19.09.2005	20,99	35		52,23	2,6	870	4,084	0,95494613	3,9	1,81E-06	1887	40,67	0,03975
Kal_22	1	2		19.09.2005	20,06	35		48,64	2,6	870	3,681	1,0594947	3,9	1,63E-06	1745	41,22	0,03845
Kal_22	2	2		19.09.2005	20,06	35		48,64	2,6	870	3,73	1,04557641	3,9	1,65E-06	1804	40,67	0,03975
Kal_23	1	4		19.09.2005	20,71	35		50,8	2,6	870	3,565	1,09396914	3,9	1,58E-06	1801	45,35	0,03844
Kal_23	2	4		19.09.2005	20,71	35		50,8	2,6	870	3,757	1,03806228	3,9	1,66E-06	1844	43,04	0,03937
1558.25a	1	1	fugtig	19.09.2005	20,18	37,28	22,016	44,49	2,0208	1475	**2,12**	1,07824197	**2,28**	7,10E-07	1809	95,63	0,03007
1558.25a	2	1	tør	19.09.2005	20,18	37,28	22,016	44,49	2,0208	1350	**1,89**	1,09588228	**2,07**	6,92E-07	1809	98,03	0,03285
1558.25b	1	3	fugtig	19.09.2005	20,14	37,35	22,055	44,49	2,0172	1475	**2,05**	1,07824197	**2,21**	6,88E-07	1822	98,28	0,0304
1558.25b	2	3	tør	19.09.2005	20,14	37,35	22,055	44,49	2,0172	1350	**1,83**	1,09588228	**2,01**	6,73E-07	1762	100,4	0,03212
1541.65a	1	1		19.09.2005	19,87	37,46	21,888	44,95	2,0536	1260	**1,87**	1,07673192	**2,01**	7,22E-07	1761	91,16	0,03425
1541.65a	2	1		19.09.2005	19,87	37,46	21,888	44,95	2,0536	1250	**1,83**	1,04181935	**1,91**	7,14E-07	1845	92,17	0,03617
1541.65b	1	3		19.09.2005	20,17	37,34	22,076	44,28	2,0058	1260	**1,75**	1,07673192	**1,89**	6,93E-07	1805	97,82	0,03541
1541.65b	2	3		19.09.2005	20,17	37,34	22,076	44,28	2,0058	1250	**1,79**	1,04181935	**1,86**	7,13E-07	1868	95,12	0,03694
1546.30a	1	1		19.09.2005	20,23	37,33	22,13	44,55	2,0131	1260	**1,83**	1,02560858	**1,88**	7,22E-07	1803	94,52	0,03514
1546.30a	2	1		19.09.2005	20,23	37,33	22,13	44,55	2,0131	1250	**1,86**	0,99307328	**1,85**	7,40E-07	1841	92,17	0,03617
1546.30b	1	3		19.09.2005	20,14	37,3	21,996	44,58	2,0267	1260	**1,84**	1,02560858	**1,88**	7,19E-07	1792	94,05	0,03484
1546.30b	2	3		19.09.2005	20,14	37,3	21,996	44,58	2,0267	1250	**1,80**	0,99307328	**1,79**	7,11E-07	1885	95,12	0,03694





Calculation group 1, channel 3 16.09 15:06

Figures 2. An example showing the measured data. 4 samples are measured simultaneously with approx. 1 measurement per sec. Channel 1 and 3 represents the 1.st measurements of the samples 1558.25 a and b respectively and channel 2 and 4 are for the calibration samples.

Målemetode

Varmeledningsevne for bergartsprøver blir målt ved en transient metode og med utstyr utviklet ved NGU. En konstant varmekilde med temperatur 300ºC ± 2ºC settes ca 10 mm over prøven. Prøven er isolert på alle sideflatene, og temperaturen måles på undersiden av prøven. Termisk diffusivitet (α) er beregnet ut fra tid-temperaturforløpet der temperaturen er logget hvert sekund over en periode på 3-4 minutter. Varmeledningsevne (K) beregnes ut fra termisk diffusivitet, tetthet (ρ) og spesifikk varmekapasitet (c_p), se ligning 1

$$K = \rho c_p \alpha \qquad \text{(lign 1.)}$$

Teorien bak målemetoden er beskrevet i Carslaw & Jaeger (1959) og Middleton (1993).

Rapportering av usikkerhet

Kvalitetskontroll skjer ved samtidig måling på standardprøver av Pyroceram 9606. Målinger som faller utenfor 2 standardavvik av varmeledningsevneverdien for Pyroceram forkastes. Varmeledningsevnen for Pyroceram for utstyrsoppsettet benyttet ved måling av prøvematerialet i analysekontrakt 2005.0297 (Lærdal 2) er bestemt fra resultater av 100 målinger (tabell 1). Spesifikk varmekapasitet for Pyroceram er satt til 870 Ws/kg,K, og tetthet er 2600 kg/m^3.

Usikkerhet for måling av termisk diffusivitet er ± 5% relativ (95% konfidensnivå, dvs. dekningsfaktor 2).

Tabell 1. Resultater fra 100 målinger av standardmateriale Pyroceram 9606.

	Varmeledningsevne (W/m,K)	Termisk diffusivitet (m^2/s)
Gjennomsnitt	4,19	1,85E-06
Median	4,19	1,85E-06
Standardavvik	0,09	3,95E-08
Minimum	4,03	1,78E-06
Maksimum	4,51	1,99E-06
Antall	100	100
%RSD	2,13 %	2,13 %
Nedre 2σ	4,02	1,78E-06
Øvre 2σ	4,37	1,93E-06

Referanser

Carslaw, H.S & Jaeger, J.C 1959: Conduction of heat in solids: *Oxford Univ Press. Inc.*

Middleton M.F. 1993: A transient method of measuring the thermal properties of rocks. *Geophysic*, 58, 357-3.

Int. J. Rock Mech. Min. Sci. & Geomech. Abstr. Vol. 15, pp. 99–103
0020-7624/78/0601-0099$02.00/0
© Pergamon Press Ltd. 1978. Printed in Great Britain

INTERNATIONAL SOCIETY FOR ROCK MECHANICS COMMISSION ON STANDARDIZATION OF LABORATORY AND FIELD TESTS

SUGGESTED METHODS FOR DETERMINING TENSILE STRENGTH OF ROCK MATERIALS

INTRODUCTION

The Commission on Standardization of Laboratory and Field Tests on Rock was appointed in 1967. Subsequent to its first meeting in Madrid in October 1968, the Commission circulated a questionnaire to all the members of the International Society for Rock Mechanics, the answers received clearly showing a general desire for standardized testing procedures. At a further meeting in Oslo in September 1969, tests were categorised and a priority for their standardization was agreed upon, as given in Table 1.

It was also decided that research tests, including many of the rock physics tests, were beyond the scope of standardization. Subsequent meetings were held in Belgrade in September 1970, in Nancy in October 1971, in Lucerne in September 1972, in Katowice in October 1973, in Denver in September 1974, in Minneapolis in September 1975 and in Salzburg in October 1976. At the Lucerne meeting the Commission was subdivided into two committees, one on standardization of laboratory tests and the second on the standardization of field tests.

The present document has been produced by the Committee on Standardization of Laboratory Tests. The present document covers Category II(1) in Table 1.

It should be emphasized that the purpose of these "Suggested Methods" is to specify rock testing procedures and to achieve some degree of standardization without inhibiting the development or improvement of techniques.

Any person interested in these recommendations and wishing to suggest additions or modifications should address his remarks to the Secretary General, International Society for Rock Mechanics, Laboratório Nacional de Engenharia Civil, Avenida do Brasil, Lisboa, Portugal.

Acknowledgements—The following persons contributed in the drafting of these "Suggested Methods": Z. T. Bieniawski (South Africa), I. Hawkes (U.S.A.).

TABLE 1. TEST CATEGORIES FOR STANDARDIZATION

Category I: *Classification and Characterization*

Rock material (laboratory tests)

(1) Density, water content, porosity, absorption.*
(2) Strength and deformability in uniaxial compression; point load strength.*
(3) Anisotropy indices.
(4) Hardness, abrasiveness.*
(5) Permeability.*
(6) Swelling and slake-durability.*
(7) Sound velocity.*
(8) Micro-petrographic descriptions.*

Rock mass (field observations)

(9) Joint systems: orientation, spacing, openness, roughness, geometry, filling and alteration.*
(10) Core recovery, rock quality designation and fracture spacing.
(11) Seismic tests for mapping and as a rock quality index.
(12) Geophysical logging of boreholes.*

Category II: *Engineering Design Tests*

Laboratory

(1) Determination of strength envelope (triaxial and uniaxial compression and tensile tests).*
(2) Direct shear tests.*
(3) Time-dependent and plastic properties.

In situ

(4) Deformability tests.*
(5) Direct shear tests.*
(6) Field permeability, ground-water pressure and flow monitoring; water sampling.*
(7) Rock stress determination.*
(8) Monitoring of rock movements, support pressures, anchor loads, rock noise and vibrations.
(9) Uniaxial, biaxial and triaxial compressive strength.
(10) Rock anchor testing.*

* Asterisks indicate that final drafts on these tests have been prepared.

Suggested Methods for Determining Tensile Strength of Rock Materials

PART 1: SUGGESTED METHOD FOR DETERMINING DIRECT TENSILE STRENGTH

1. SCOPE

This method of test is intended to measure directly the uniaxial tensile strength of a rock specimen of regular geometry. The test is mainly intended for classification and characterization of intact rock.

2. APPARATUS

(a) A suitable machine shall be used for applying and measuring the axial load to the specimen. It shall be of sufficient capacity and capable of applying load at a rate conforming to the requirements set in section 3. It shall be verified at suitable time intervals and shall comply with accepted national requirements such as prescribed in either ASTM Methods E4, Verification of Testing Machines or British Standard 1610, Grade A or Deutsche Normen DIN 51 220 and DIN 51 223, Klasse 1.

(b) Cylindrical metal caps shall be cemented to the specimen ends, providing a means through which the direct uniaxial tensile load can be applied. The diameter of the metal caps shall not be less than that of the test specimen nor shall it exceed the test specimen diameter by more than 2 mm. Caps shall have a thickness of at least 15 mm. Caps shall be provided with a suitable linkage system for load transfer from the loading device to the test specimen. The linkage system shall be so designed that the load will be transmitted through the axis of the test specimen without the application of bending or torsional stresses. The length of the linkages at each end shall be at least twice the diameter of the metal caps.*

3. PROCEDURE

(a) The test specimens shall be right circular cylinders having a height to diameter ratio of 2.5:3.0 and a diameter preferably of not less than NX core size, approximately 54 mm. The diameter of the specimen should be related to the size of the largest grain in rock by the ratio of at least 10:1.

(b) The ends of the specimen shall be generally smooth and flat.† The ends shall not depart from perpendicularity to the axis of the specimen by more than 0.001 radian (about 3.5 min) or 0.05 in 50 mm.

(c) The sides of the specimen shall be smooth and free of abrupt irregularities and straight to within 0.1 mm over the full length of the specimen.

(d) The diameter of the test specimen shall be measured to the nearest 0.1 mm by averaging two diameters measured at right angles to each other at about the mid-height of the specimen. The average diameter shall be used for calculating the cross-sectional area. The height of the specimen shall be determined to the nearest 1.0 mm.

(e) Samples shall be stored, for no longer than 30 days, in such a way as to preserve the natural water content, as far as possible, until the time of specimen preparation. Following their preparation, the specimens shall be stored prior to testing for 5–6 days in an environment of 20°C ± 2°C and 50% ± 5% humidity.‡ This moisture condition shall be reported in accordance with "Suggested method for determination of the water content of a rock sample", Method 1, Committee on Laboratory Tests, Document No. 2, Final Draft, November 1972.

(f) The metal caps should be cemented to the specimen in such a manner as to ensure alignment of the cap axes with the logitudinal axis of the specimen. The thickness of the cement layer should not exceed 1.5 mm at each end. After the cement has hardened sufficiently to exceed the tensile strength of the rock, the test speciment shall be placed in the testing machine in such a way that the load transfer system is properly aligned.

(g) The tensile load on the specimen shall be applied continuously at a constant stress rate such that failure will occur within 5 min of loading; alternatively the stress rate shall be within the limits of 0.5 MPa/s to 1.0 MPa/s.

(h) The maximum load on the specimen shall be recorded to within 1%.

(i) The number of specimens per sample tested should be determined from practical considerations but at least five are preferred.

4. CALCULATIONS

The tensile strength of the specimen shall be calcu-

* According to the *Annual Book of ASTM Standards*, Test D2936-71, a roller or link chain of suitable capacity has been found to perform quite well in this application. Because roller chain flexes in one plane only, the upper and lower segments are positioned at right angles to each other to reduce bending in the specimen. Ball-and-socket, cable or similar arrangements have been found to be generally unsuitable because their tendency for bending and twisting makes the assembly unable to transmit a purely direct tensile stress to the test specimen.

‡ In direct tension tests, the condition of the specimen ends with regard to the degree of flatness and smoothness is not as critical as in compression tests. End surfaces such as result from sawing with a diamond cut-off wheel are entirely adequate.

† It is recognised that in some cases for some materials (e.g. shale), it may be desired to test specimens in other moisture conditions, for example, saturated or oven dry at 105°C. Such conditions shall be noted in the test report.

lated by dividing the maximum load applied to the specimen by the original cross-sectional area.

5. REPORTING OF RESULTS

(a) Lithologic description of the rock.

(b) Orientation of the axis of loading with respect to specimen anisotropy, e.g. bedding planes, foliation, etc.

(c) Source of sample, including: geographic location, depth and orientation, dates of sampling and storage history and environment.

(d) Number of specimens tested.

(e) Specimen diameter and height.

(f) Water content and degree of saturation at time of test.

(g) Test duration and/or stress rate.

(h) Date of testing and type of testing machine.

(i) Mode of failure, e.g. location and orientation of failure surface.

(j) Any other observations or available physical data, such as specific gravity, porosity and permeability, citing the method of determination of each.

(k) The tensile strength for each specimen in the sample, expressed to three significant figures, together with the average result for the sample. The pascal (Pa) or kilopascal (kPa) or mega-pascal (MPa) shall be used as the unit of stress and strength.

(l) Should it be necessary in some instances to test specimens that do not comply with the above specifications, these facts shall be noted in the test report.

PART 2: SUGGESTED METHOD FOR DETERMINING INDIRECT TENSILE STRENGTH BY THE BRAZIL TEST

1. SCOPE

This test is intended to measure the uniaxial tensile strength of prepared rock specimens indirectly by the Brazil test. The justification for the test is based on the experimental fact that most rocks in biaxial stress fields fail in tension at their unaxial tensile strength when one principal stress is tensile and the other finite principal stress is compressive with a magnitude not exceeding three times that of the tensile principal stress.

2. APPARATUS

(a) Two steel loading jaws designed so as to contact a disc-shaped rock sample at diametrically-opposed surfaces over an arc of contact of approx 10° at failure. The suggested apparatus to achieve this is illustrated in Fig. 1. The critical dimensions of the apparatus are the radius of curvature of the jaws, the clearance and length of the guide pins coupling the two curved jaws

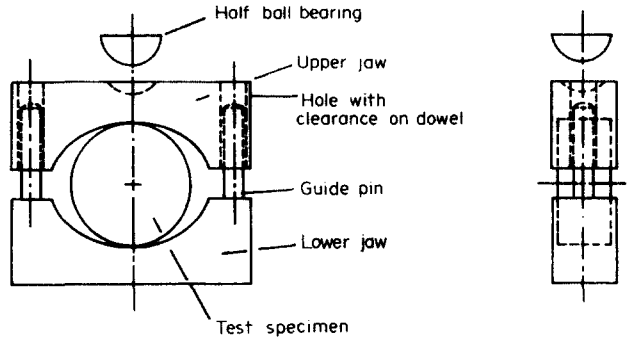


Fig. 1. Apparatus for Brazil test.

and the width of the jaws. These are as follows: Radius of jaws—1.5 × specimen radius; guide pin clearance—permit rotation of one jaw relative to the other by 4×10^{-3} rad out of plane of the apparatus (25 mm penetration of guide pin with 0.1 mm clearance); width of jaws—1.1 × specimen thickness. The remaining dimensions can be scaled from Fig. 1. The upper jaw contains a spherical seating conveniently formed by a 25-mm diameter half-ball bearing.

(b) Double thickness (0.2–0.4 mm) adhesive paper strip (masking tape) with a width equal to or slightly greater than the specimen thickness.

(c) A suitable machine for applying and measuring compressive loads to the specimen. It shall be of sufficient capacity and be capable of applying load at a rate conforming to the requirements set out in section 3. It shall be verified at suitable time intervals and shall comply with accepted national requirements such as prescribed in either ASTM Methods E4, Verification of Testing Machines or British Standard 1610, Grade A or Deutsche Normen DIN 51 220 and DIN 51 223, Klasse 1.

(d) A spherical seat, if any, of the testing machine crosshead shall be placed in a locked position, the two loading surfaces of the machine being parallel to each other.

(e) It is preferable but not obligatory that the testing machine be fitted with a chart recorder to record load against displacement to aid in the measurement of the failure load.

3. PROCEDURE

(a) The test specimens should be cut and prepared using clean water. The cylindrical surfaces should be free from obvious tool marks and any irregularities across the thickness of the specimen should not exceed 0.025 mm. End faces shall be flat to within 0.25 mm and square and parallel to within 0.25°.

(b) Specimen orientation shall be known and the water content controlled or measured and reported in accordance with the "Suggested method for determination of water content of a rock sample", Method 1, ISRM Committee on Laboratory Tests, Document No. 2, November 1972.

(c) The specimen diameter shall not be less than NX

core size, approximately 54 mm, and the thickness should be approximately equal to the specimen radius.

(d) The test specimen shall be wrapped around its periphery with one layer of the masking tape and mounted squarely in the test apparatus such that the curved platens load the specimen diametrally with the axes of rotation for specimen and apparatus coincident.

(e) Load on the specimen shall be applied continuously at a constant rate such that failure in the weakest rocks occurs within 15–30 s. A loading rate of 200 N/s is recommended.

(f) Where the testing machine is fitted with a force/displacement recorder, a record should be taken during testing—so that the load for primary fracture can be precisely determined (in some cases load continues to increase after primary failure as the split specimen is still bearing load). If a load/displacement recorder is not available on the testing machine, then care must be taken by the operator to detect the load at primary failure. At primary failure there will be a brief pause in the motion of the indicator needle. However, the difference between the load at primary failure and ultimate load bearing capacity is at most only about 5%.

(g) The number of specimens per sample tested should be determined from practical considerations, but normally ten are recommended.

4. CALCULATIONS

The tensile strength of the specimen σ_t, shall be calculated by the following formula:

$$\sigma_t = 0.636\, P/Dt \text{ (MPa)}$$

where P is the load at failure (N), D is the diameter of the test specimen (mm), t is the thickness of the test specimen measured at the center (mm).

5. REPORTING OF RESULTS

(a) Lithologic description of the rock.

(b) Orientation of the axis of loading with respect to specimen anisotropy, e.g. bedding planes, foliation, etc.

(c) Source of sample, including: geographic location, depth and orientation, dates and method of sampling and storage history and environment.

(d) Number of specimens tested.

(e) Specimen diameter and height.

(f) Water content and degree of saturation at time of test.

(g) Test duration and stress rate.

(h) Date of testing and type of testing machine.

(i) Mode of failure.

(j) Any other observations or available physical data such as specific gravity, porosity and permeability, citing the method of determination for each.

(k) The tensile strength for each specimen in the sample, expressed to three significant figures, together with the average result for the sample.

REFERENCES

Mellor M. & Hawkes I. Measurement of tensile strength by diametral compression of discs and annuli. *Engng Geol.* **5**, 173–225 (1971).

Int. J. Rock Mech. Min. Sci. & Geomech. Abstr. Vol. 15, pp. 53–58
© Pergamon Press Ltd 1978. Printed in Great Britain
0020-7624/78/0401-0053 $02.00/0

INTERNATIONAL SOCIETY FOR ROCK MECHANICS

COMMISSION ON STANDARDIZATION OF LABORATORY AND FIELD TESTS

SUGGESTED METHODS FOR DETERMINING SOUND VELOCITY

INTRODUCTION

The Commission on Standardization of Laboratory and Field Tests on Rock was appointed in 1967. Subsequent to its first meeting in Madrid in October 1968, the Commission circulated a questionnaire to all the members of the International Society for Rock Mechanics, the answers received clearly showing a general desire for standardized testing procedures. At a further meeting in Oslo in September 1969, tests were categorized and a priority for their standardization was agreed upon, as given in Table 1.

It was also decided that research tests, including many of the rock physics tests, were beyond the scope of standardization. Subsequent meetings were held in Belgrade in September 1970, in Nancy in October 1971, in Lucerne in September 1972, in Katowice in October 1973, in Denver in September 1974, in Minneapolis in September 1975, and in Salzburg in October 1976. At the Lucerne meeting the Commission was subdivided into two committees, one on standardization of laboratory tests and the second on the standardization of field tests.

The present document has been produced by the Committee on Standardization of Laboratory Tests. The present document covers Category I (7) in Table 1.

It should be emphasized that the purpose of these "Suggested Methods" is to specify rock testing procedures and to achieve some degree of standardization without inhibiting the development or improvement of techniques.

Any person interested in these recommendations and wishing to suggest additions or modifications should address his remarks to: The Secretary General, International Society for Rock Mechanics, Laboratório Nacional de Engenharia Civil, Avenida do Brasil, Lisboa, Portugal.

Acknowledgements—The following persons contributed in the drafting of these "Suggested Methods": F. Rummel (Germany) and W. L. van Heerden (South Africa).

TABLE 1. TEST CATEGORIES FOR STANDARDIZATION

Category I: Classification and Characterization

Rock material (laboratory tests)

(1) Density, water content, porosity, absorption.*
(2) Strength and deformability in uniaxial compression; point load strength.*
(3) Anisotropy indices.
(4) Hardness, abrasiveness.*
(5) Permeability.
(6) Swelling and slake-durability.*
(7) Sound velocity.*
(8) Micro-petrographic descriptions.*

Rock mass (field observations)

(9) Joint systems: orientation, spacing, openness, roughness, geometry, filling and alteration.*
(10) Core recovery, rock quality designation and fracture spacing.
(11) Seismic tests for mapping and as a rock quality index.
(12) Geophysical logging of boreholes.*

Category II: Engineering Design Tests

Laboratory

(1) Determination of strength envelope (triaxial and uniaxial compression and tensile tests).*
(2) Direct shear tests.*
(3) Time-dependent and plastic properties.

In situ

(4) Deformability tests.*
(5) Direct shear tests.*
(6) Field permeability, ground-water pressure and flow monitoring; water sampling.
(7) Rock stress determination.*
(8) Monitoring of rock movements, support pressures, anchor loads, rock noise and vibrations.
(9) Uniaxial, biaxial and triaxial compressive strength.
(10) Rock anchor testing.*

* Asterisks indicate that final drafts on these tests have been prepared.

Suggested Methods for Determining Sound Velocity

1. SCOPE

This test is intended as a method to determine the velocity of propagation of elastic waves in laboratory rock testing. Three different variations of the method are given. These are: the high frequency ultrasonic pulse technique, the low frequency ultrasonic pulse technique and the resonant method.

2. APPARATUS

Although there are three different methods, the electronic components should, as far as possible, be chosen so as to be applicable to all three methods. The same rock or even the same sample can be used for all three methods. Consideration should of course be given to the respective frequencies used for the different methods. The electronic components should be impedance matched and have shielded leads to ensure efficient energy transfer. To prevent damage to the system allowable voltage inputs should not be exceeded.

First method

(a) Pulse generator unit:
pulse form: sine-, square, step-wave pulse;
pulse width: 1–10 s;
frequency range: 100 kHz–2 MHz;
repetition frequency: 10–10^3 repetitions per second;
pulse voltage: to be compatible to transducer used, as high as transducers allow.

The pulse generator must have a trigger-pulse output to trigger an oscilloscope (trigger-signal).

(b) Transducers:
transmitter: converts electrical pulses into mechanical pulses;
receiver: converts mechanical pulses into electrical pulses;
frequency response: flat from 100 kHz to 2 MHz, if possible.

Environmental conditions such as temperature, moisture, humidity and impact should be considered in selecting the transducer element.

Piezoelectric ceramics (e.g. barium titanate or lead-zirconate–titanate) in the form of plates, discs, rods, rings or spheres to generate pulses in the frequency range 100 kHz–2 MHz are recommended. It is usually necessary to use different piezoelectric transducers for compressional or shear-wave transmission and receiving, e.g. cylindrical discs (radius $\gg$ thickness) acting in the thickness and radial mode for transmitting and receiving compressional waves; shear plates operating in the shear mode for transmitting and receiving shear waves.

(c) Band pass or high pass filter suitable for the frequencies mentioned above.

(d) Wide band low noise pre-amplifier.

(e) Time mark generator to control pulse repetition and to give time marks at the CRO.

(f) Cathode ray oscilloscope (CRO):
dual beam CRO is recommended;
max. sweeprate: 0.1 μs/cm;
band width: must have essentially flat response from d.c. to 5 MHz or higher.

(g) Electronic counter with provisions for time interval measurements is desirable.

Two possible layouts of the electronic components are shown in Fig. 1.

Second method

Low frequency ultrasonic pulse technique for bar-like specimens with a maximum lateral dimension up to 10 cm.

(a) Pulse generator unit (e.g. function generator):
frequency range: 2–30 kHz (if the generator mentioned in the first method has a low frequency range it can obviously be used here);
repetition frequency: 10–100 repetitions per second;
pulse voltage: same as in first method.

(b) Transducers:

(i) Transmitter: piezo-electric ceramics or magneto-strictive elements, which are capable to generate high amplitude pulses (depending on the rock type and specimen dimensions) in the frequency range 2–30 kHz.

(ii) Receivers: piezo-electric ceramics with flat frequency response in the frequency range 2–30 kHz or magneto-strictive elements.

(c) Filters, amplifiers, CRO, time-marker analog to first method with consideration of the low frequency range.

Third method

(a) Sine-wave generator (e.g. function generator) with a frequency range of 1–100 kHz and pulse voltage as in first and second methods.

(b) Transducers:

(i) Transmitter: piezo-electric ceramics or magneto-strictive element with *flat* frequency response in the range 1–100 kHz.

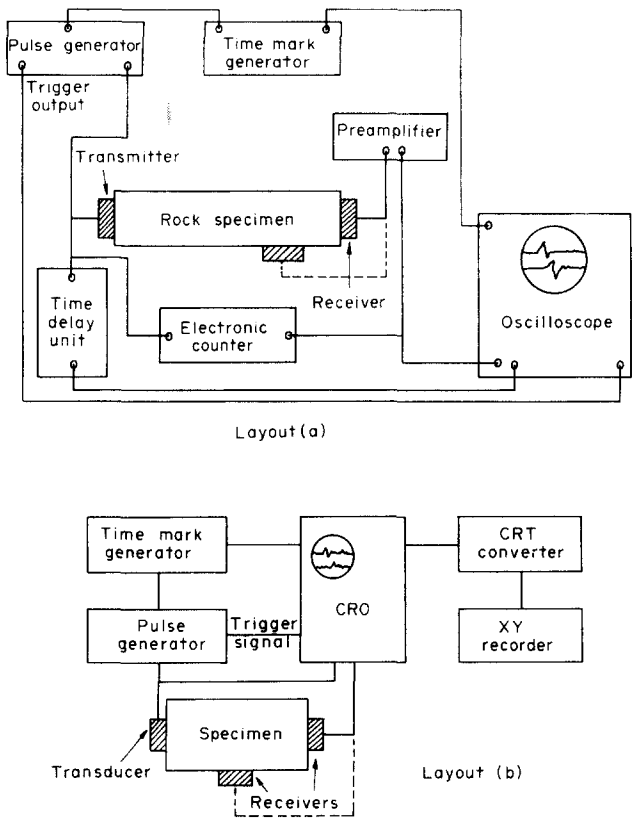


Fig. 1. Two possible layouts of electronic components for the first method.

(ii) Receiver: piezo-electric ceramics (similar to the transmitter) or capacitive pick-up (condensator microphone principle) with flat frequency response from 1–100 kHz (first possible resonant frequency of any mode should be greater than 100 kHz).

(c) CRO, amplifiers analog to record method.

The layout of the electronic components is shown in Fig. 2.

3. PROCEDURE

Care should be exercised in core drilling, handling, sawing, grinding and lapping the test specimen to minimize mechanical damage. The surface area under each transducer shall be sufficiently plane to provide good coupling.

Drying of specimens may be carried out by using a desiccator. Saturated specimens shall remain submerged in water up to the time of testing. If the velocity is to be determined with the *in-situ* condition, care must be exercised during the preparation procedure. It is also suggested that both the sample where the specimen is taken from as well as the specimen, be stored in moisture-proof bags. Dry surface-preparation procedures may be employed.

First method

This method is for the determination of velocities of compressional (dilatational, longitudinal, P-) and shear (rotational, transversal, S-) waves in rock specimens of effectively infinite extent compared to the wave length of the pulse used. The condition of infinite extent is satisfied if the average grain size < wave length of the pulse < minimum specimen dimension.

(a) Rectangular blocks, cylindrical cores or even spheres (for determination of elastic symmetry of anisotropic rocks) are recommended as specimens. The lateral minimum dimension (normal to the direction of wave propagation) is recommended to be not less than 10 times the wave-length.* The travel distance of the pulse through the rock shall be at least 10 times the average grain size.

(b) The transmitter is pressed to the centre of a plane normal to the direction of wave propagation by a stress of about 10 N/cm^2. Energy transmission between the transducers and the test specimen can be improved by:

(i) Lapping the surfaces of the end planes to make them smooth and flat;

(ii) Coupling the transducer elements to the end planes by a thin film of grease, vaseline, glycerin, putty or oil;

(iii) Hard coupling with an epoxy type adhesive or with phenyl salicylate;

(c) There are two possibilities to position the receivers:

(i) Pulse transmission technique: The receiver is positioned on a plane opposite to the plane to which the transmitter is pressed (Fig. 3a). The velocities of either P- or S-waves (v_p, v_s) are calculated from the measured travel time and the distance between transmitter and receiver.

(ii) "Seismic" profiling technique: The receiver is positioned on the side of the specimen (Fig. 3b). By varying the distance d between receiver and transmitter it is possible to obtain curves of travel time vs distance, d for both P- and S-waves. The velocities are calculated from these curves. This latter method is highly recommended if the specimen size is suitable.

(d) Increase the voltage output of the pulse generator, the gain of the amplifier, and the sensitivity of the oscilloscope and counter to an optimum level, giving a steeper pulse front to permit more accurate time measurements. The optimum level is just below that at which electromagnetic noise reaches an intolerable

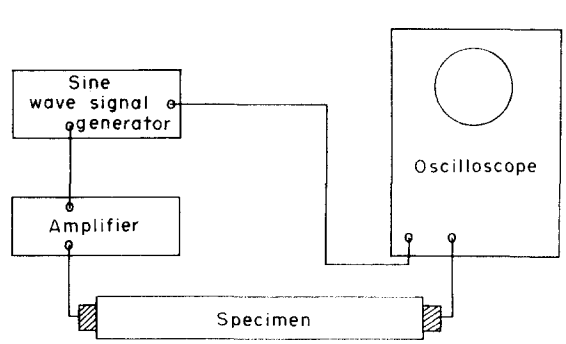


Fig. 2. Layout of components for the third method.

* ASTM recommendation D 2845-69 stipulates five times the wavelength.

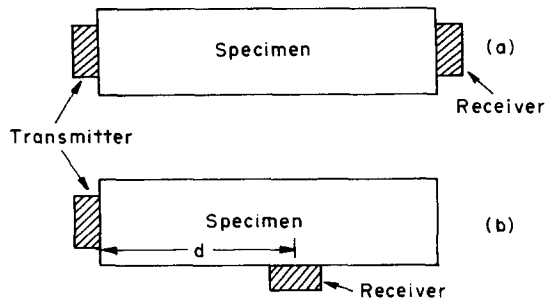


Fig. 3. Positions of transmitter and receiver on the specimen (first method).

magnitude or triggers the counter at its lowest triggering sensitivity. The noise level shall not be greater than one tenth of the amplitude of the first peak of the signal from the receiver. Measure the travel time to a precision and accuracy of 1 part in 100 for compression waves and 1 part in 50 for shear waves by using the delaying circuits in conjunction with the oscilloscope or setting the counter to its highest usable precision.

(e) The oscilloscope is used with the time-delay circuit to display both the direct pulse and the first arrival of the transmitted pulse, and to measure the travel time. Characteristically, the first arrival displayed on the oscilloscope consists of a curved transition from the horizontal zero-voltage trace followed by a steep, more or less linear, trace. Select the first break in a consistent manner for both the test measurement and the zero-time determination. Select it either at the beginning of the curved transition region or at the zero-voltage intercept of the straight line portion of the first arrival.

(f) The counter is triggered to start by the direct pulse applied to the transmitter and is triggered to stop by the first arrival of the pulse reaching the receiver. Because a voltage change is needed to trigger the counter, it cannot accurately detect the first break of a pulse. To make the most accurate time-interval measurements possible, increase the counter's triggering sensitivity to an optimum without causing spurious triggering by extraneous electrical noise.

(g) Determine the zero time of the circuit including both transducers and the travel-time measuring device and apply the correction to the measured travel times. This factor will remain constant for a given rock and stress level if the circuit characteristics do not change. Determine the zero time accordingly to detect any changes. Determine it by:

(1) Placing the transducers in direct contact with each other and measuring the delay directly (this method is not recommended for shear crystals where slight misalignment can produce large errors); or

(2) Measuring the apparent travel time of some uniform material (such as steel) as a function of length, and then using the zero-length intercept of the line through the data points as the correction factor. (This method is particularly recommended for shear waves.)

(h) Since the first transmitted arrival is that of the compression wave, its detection is relatively easy. The shear-wave arrival, however, may be obscured by vibrations due to ringing of the transducers and reflections of the compression wave. The amplitude of the shear wave relative to the compression wave may be increased and its arrival time determined more accurately by means of thickness shear-transducer elements. This type of element generates some compressional energy, so that both waves may be detected. Energy transmission between the specimen and each transducer may be improved by using a thin layer of a coupling medium such a phenyl salicylate, high-vacuum grease, or resin, and by pressing the transducer against the specimen with a small seating force.

(i) For specimens subjected to uniaxial stress fields, first arrivals of compression waves are usually well defined. However, the accurate determination of shear-wave first arrivals for specimens under stress is complicated by mode conversions at the interfaces on either side of the face plate and at the free surface.

(j) Distinguishing the shear wave arrival time can be performed more easily on specimens whose length is optimized. For example, a h/w ratio of 2:1 is often preferable to a specimen whose h/w ratio is 1:1.

Second method

This method is for the determination of the velocity of dilatational and torsional waves in bar or rod-like rock specimens (bar waves, one-dimensional wave propagation). This method is suitable for specimens which are long compared to the diameter (length to diameter ratio >3) and the wave length of the pulse should be long compared to the diameter (wave length to diameter ratio >5).

(a) Dimensions should be as stated above. For the pulse transmission technique and the resonant frequency technique both the end planes of the specimen should be flat and parallel to within 0.005 mm/mm of the lateral dimension.

(b) Rock cores are positioned on the sample holder of an acoustical bench. The cores have at least a length to diameter ratio of >3. The transmitter, generating a sine wave of a wave-length >5 times the core diameter, is pressed to a saw-cut flat end plane (normal to the core axis) by a stress of approx 10 N/cm^2 for v_p measurement. For v_s measurement positioning of the transmitter according to Fig. 4 is recommended.

(c) There are two possibilities in the positioning of the receiver (analog to (c) in first method):

(i) pulse transmission: the receiver is positioned at the opposite flat plane of the core. Both end planes should be parallel to within about one degree; ball joints may be used

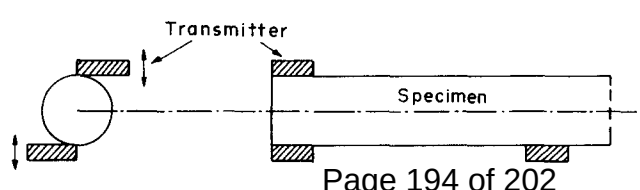


Fig. 4. Positions of transmitters and receiver for the second method.

(ii) seismic profiling: the receiver is moved along the surface of the core parallel to the core-axis.

(d) The remainder of the procedure is the same as for the first method.

Third method

By determination of the resonance frequency of both dilatational and torsional vibrations of bar or rod-like cylindrical rock specimens with length to diameter ratio >3 (wave-length to diameter ratio >6) the velocity of bar waves, both dilatational and torsional (one-dimensional wave propagation, see second method) can be calculated.

(a) Dimensions should be as stated above. For the pulse transmission technique and the resonant frequency technique both the end planes of the specimen should be flat and parallel to within 0.005 mm/mm of the lateral dimension.

(b) Rock cores with length to diameter ratio >3 are placed on the sample holder of an acoustical bench. Both end planes are ground plane to within 10^{-3} mm and parallel to within one degree.

(c) To determine the longitudinal resonant frequency both the transmitter and receiver are pressed to the centre of both the end planes by means of *soft* springs (maximum load: 10 N) to ensure free end condition for the specimen (capacitive receivers are recommended because of this purpose). Care should be taken in positioning the specimen on a sample holder to ensure free specimen condition.

(d) Transmitter frequency is varied to give maximum readings on the CRO. At least the first three modes of the resonant frequency are recorded.

(e) For the determination of torsional resonant frequency the transmitter should be positioned so as to introduce torsional vibrations.

4. CALCULATION

One- or three-dimensional equations of wave propagation are used.

First and second methods

(a) Velocities are calculated from travel times measured and the distance, d, between transmitter and receiver by using the equations:

$$v_p = d \cdot t_p^{-1}$$

$$v_s = d \cdot t_s^{-1}$$

where v_p is the velocity of the longitudinal wave, v_s is the velocity of the shear wave, t_p and t_s are the times which the P- and S-wave, respectively, took to travel the distance d.

(b) If seismic profiling technique was used the velocities are given by the slope of the curve travel time vs distance d.

Third method

The bar wave velocities are calculated from

$$v_d = 2\,l f_0$$

where l is the length of the bar or rod, and f_0 is the resonant frequency of zero mode of either dilatation or torsional vibrations.

5. REPORTING OF RESULTS

The report should include the following information:

(a) Rock type, exact origin (e.g. country, area, geological formation, quarry, depth of drill holes, special geological or structural feature where taken from).

(b) Specimen dimensions and specimen geometry.

(c) How rock material was obtained (e.g. blasting in a quarry, drilling on fresh or weathered surface).

(d) Petrofabrical and petrographical description; micro-crack distribution.

(e) Sample preparation (quality of cores, of end-planes, number of cores taken from one larger block, orientation of cores in relation to major geological features).

(f) Description of experimental testing method: data of electrical pulse source; data of transducers (an amplitude-frequency plot is highly recommended); coupling of transducers to the specimen.

(g) Stress field applied to the specimen.

(h) All available physical properties of the rock (particularly density, porosity, permeability).

(i) velocity data at normal conditions (room temperature, atmospheric pressure, room temperature dried).

(j) Repeatability.

(k) Velocity variations among samples at constant testing parameters; average velocities; mean error; maximum deviations.

(l) In the case of "sesmic" profiling: travel-time–distance curves.

(m) One representative CRO-picture or outprint at the XY-recorder.

(n) Technique to obtain travel time readings (e.g. first deviation of transmitter pulse to first deviation of receiver pulse at CRO; first maximum of receiver wavelet, etc.).

(o) Velocity-stress data (if measured).

(p) Compressional wave velocity, v_p in m/s.

(q) Shear wave velocity, v_s in m/s.

(r) Bar wave velocity: dilatational, $v_{d,l}$ in m/s
torsional, $v_{d,t}$ in m/s.

(s) Density, in kg/m^3.

(t) Stress, in Pa.

(u) Geometrical dimensions, in mm.

Note

(i) A method introducing torsional and longitudinal vibrations in a rod or bar was developed by Obert (Obert L. S., Windes L. & Duvall W. I. Standardized tests for determining the physical properties of mine rock. *U.S. Bur. Mines Rep. Invest.* 3891 (1946).

(ii) Many rocks which are porous, slightly weathered or have micro-cracks are quite sensitive to stress levels (and/or saturation) and for practical problems it may be desirable to test them at the saturation and maximum principal stress level to which they will be subjected in the applied case.

Suggested Methods for Determining the Uniaxial Compressive Strength and Deformability of Rock Materials

PART 1. SUGGESTED METHOD FOR DETERMINATION OF THE UNIAXIAL COMPRESSIVE STRENGTH OF ROCK MATERIALS

1. SCOPE

This method of test is intended to measure the uniaxial compressive strength of a rock sample in the form of specimens of regular geometry. The test is mainly intended for strength classification and characterization of intact rock.

2. APPARATUS

(a) A suitable machine shall be used for applying and measuring axial load to the specimen. It shall be of sufficient capacity and capable of applying load at a rate conforming to the requirements set in Section 3. It shall be verified at suitable time intervals and shall comply with accepted national requirements such as prescribed in either ASTM Methods E4: Verification of Testing Machines or British Standard 1610, Grade A or Deutsche Normen DIN 51 220, DIN 51 223, Klasse 1 and DIN 51 300.

(b) A spherical seat, if any, of the testing machine, if not complying with specification 2(d) below, shall be removed or placed in a locked position, the two loading faces of the machine being parallel to each other.

(c) Steel platens in the form of discs and having a Rockwell hardness of not less than HRC58 shall be placed at the specimen ends. The diameter of the platens shall be between D and D + 2 mm where D is the diameter of the specimen. The thickness of the platens shall be at least 15 mm or D/3. Surfaces of the discs should be ground and their flatness should be better than 0.005 mm.

(d) One of the two platens shall incorporate a spherical seat. The spherical seat should be placed on the upper end of the specimen. It should be lightly lubricated with mineral oil so that it locks after the deadweight of the cross-head has been picked up. The specimen, the platens and spherical seat shall be accurately centred with respect to one another and to the loading machine. The curvature centre of the seat surface should coincide with the centre of the top end of the specimen.

3. PROCEDURE

(a) Test specimens shall be right circular cylinders having a height to diameter ratio of 2.5–3.0 and a diameter preferably of not less than NX core size, approximately 54 mm. The diameter of the specimen should be related to the size of the largest grain in the rock by the ratio of at least 10:1.

(b) The ends of the specimen shall be flat to 0.02 mm and shall not depart from perpendicularity to the axis of the specimen by more than 0.001 radian (about 3.5 min) or 0.05 mm in 50 mm.

(c) The sides of the specimen shall be smooth and free of abrupt irregularities and straight to within 0.3 mm over the full length of the specimen.

(d) The use of capping materials or end surface treatments other than machining is not permitted.

(e) The diameter of the test specimen shall be measured to the nearest 0.1 mm by averaging two diameters measured at right angles to each other at about the upper-height, the mid-height and the lower height of the specimen. The average diameter shall be used for calculating the cross-sectional area. The height of the specimen shall be determined to the nearest 1.0 mm.

(f) Samples shall be stored, for no longer than 30 days, in such a way as to preserve the natural water content, as far as possible, and tested in that condition.* This moisture condition shall be reported in accordance with "Suggested method for determination of the water content of a rock sample", Method 1, ISRM Committee on Laboratory Tests, Document No. 2, First Revision, December 1977.

(g) Load on the specimen shall be applied continuously at a constant stress rate such that failure will occur within 5–10 min of loading, alternatively the stress rate shall be within the limits of 0.5–1.0 MPa/s.

(h) The maximum load on the specimen shall be

* It is recognized that in some cases for some materials it may be desired to test specimens in other moisture conditions, for example, saturated or oven dry at 105°C. Such conditions shall be noted in the test report.

recorded in newtons (or kilonewtons and meganewtons where appropriate) to within 1%.

(j) The number of specimens tested should be determined from practical considerations but at least five are preferred.

4. CALCULATIONS

(a) The uniaxial compressive strength of the specimen shall be calculated by dividing the maximum load carried by the specimen during the test, by the original cross-sectional area.

5. REPORTING OF RESULTS

(a) Lithologic description of the rock.

(b) Orientation of the axis of loading with respect to specimen anisotropy, e.g. bedding planes, foliation, etc.

(c) Source of sample, including: geographic location, depth and orientations, dates and method of sampling and storage history and environment.

(d) Number of specimens tested.

(e) Specimen diameter and height.

(f) Water content and degree of saturation at time of test.

(g) Test duration and stress rate.

(h) Date of testing and type of testing machine.

(i) Mode of failure, e.g. shear, axial cleavage, etc.

(j) Any other observations or available physical data such as specific gravity, porosity and permeability citing the method of determination for each.

(k) Uniaxial compressive strength for each specimen in the sample, expressed to three significant figures, together with the average result for the sample. The pascal (Pa) or its multiples shall be used as the unit of stress and strength.

(l) Should it be necessary in some instances to test specimens that do not comply with specifications as stated above these facts shall be noted in the test report.

REFERENCES

1. Obert L., Windes S. L. & Duvall W. I. Standardized tests for determining the physical properties of mine rocks. *U.S. Bureau of Mines Report of Investigations.* No. 3891, 1946, 67 p.
2. International Bureau for Rock Mechanics. Richtlinien zur Durchführung von Druckversuchen an Gesteinen im Bergbau. *Bericht*, 5. *Ländertreffen des I.B.G.*, Akademie-Verlag, Berlin, 1964, pp. 21–25.
3. U.S. Corps of Engineers. Strength parameters of selected intermediate quality rocks—testing procedures. *Missouri River Division Laboratory Reports.* No. 64/493, July 1966, pp. 1A–6A; 1B–7B.
4. ASTM. Standard method of test for unconfined compressive strength of rock core specimens. *American Society for Testing and Materials.* ASTM Designation D-2938-71a.
5. Hawkes I. & Mellor M. Uniaxial testing in rock mechanics laboratories. *Engng. Geol.* **4**, July 1970, pp. 177–285.

PART 2. SUGGESTED METHOD FOR DETERMINING DEFORMABILITY OF ROCK MATERIALS IN UNIAXIAL COMPRESSION

1. SCOPE

This method of test is intended to determine stress-strain curves and Young's modulus and Poisson's ratio in uniaxial compression of a rock specimen of regular geometry. The test is mainly intended for classification and characterization of intact rock.

2. APPARATUS

(a) to (d)—See Part 1.

(e) Electrical resistance strain gauges, linear variable differential transformers, compressometers, optical devices or other suitable measuring devices. Their design shall be such that the average of two circumferential and two axial strain measurements, equally spaced, can be determined for each increment of load. The devices should be robust and stable, with strain sensitivity of the order of 5×10^{-6}.

Both axial and circumferential strains shall be determined within an accuracy of 2% of the reading and a precision of 0.2 percent of full scale.

If electrical resistance strain gauges are used, the length of the gauges over which axial and circumferential strains are determined shall be at least ten grain diameters in magnitude and the gauges should not encroach within D/2 of the specimen ends, where D is the diameter of the specimen.

If dial micrometers of LVDT's are used for measuring axial deformation due to loading, these devices should be graduated to read in 0.002 mm units and accurate within 0.002 mm in any 0.02 mm range and within 0.005 mm in any 0.25 mm range. The dial micrometer or LVDT's should not encroach within D/2 of the specimen ends.

(f) An apparatus for recording the loads and deformations; preferably an X–Y recorder capable of direct plotting of load-deformation curves.

3. PROCEDURE

(a) to (e)—See Part 1.

(f) Moisture can have a significant effect on the deformability of the test specimen. When possible, *in situ* moisture conditions should be preserved until the time of the test. When the characteristic of the rock material under conditions varying from saturation to dry is required, proper note shall be made of moisture conditions so that correlation between deformability and moisture content can be made. Excess moisture can create a problem of adhesion of strain gauges which may require making a change in moisture content of the sample. The moisture condition shall be reported

in accordance with "Suggested method for determination of the water content of a rock sample", Method 1, ISRM Committee on Laboratory Tests, Document No. 2, December 1977.

(g) Load on the specimen shall be applied continuously at a constant stress rate such that failure will occur within 5–10 min of loading, alternatively the stress rate shall be within the limits of 0.5–1.0 MPa/s.

(h) Load and axial and circumferential strains or deformations shall be recorded at evenly spaced load intervals during the test, if not continually recorded. At least ten readings should be taken over the load range to define the axial and diametric stress-strain curves.

(i) It is sometimes advisable for a few cycles of loading and unloading to be performed.

(j) The number of specimens instrumented and tested under a specified set of conditions shall be governed by practical considerations but at least five are preferred.

4. CALCULATIONS

(a) Axial strain, ϵ_a, and diametric strain, ϵ_d, may be recorded directly from strain indicating equipment or may be calculated from deformation readings depending upon the type of instrumentation such as discussed in paragraph 2(e).

(b) Axial strain is calculated from the equation

$$\epsilon_a = \frac{\Delta l}{l_0}$$

where

l_0 = original measured axial length

Δl = change in measured axial length (defined to be positive for a decrease in length)

(c) Diametric strain may be determined either by measuring the changes in specimen diameter or by measuring the circumferential strain. In the case of measuring the changes in diameter, the diametric strain is calculated from the equation

$$\epsilon_d = \frac{\Delta d}{d_0}$$

where

d_0 = original undeformed diameter of the specimen

Δd = change in diameter (defined to be negative for an increase in diameter)

In the case of measuring the circumferential strain ϵ_d, the circumference is $C = \pi d$, thus the change in circumference is $\Delta C = \pi \Delta d$. Consequently, the circumferential strain, ϵ_c, is related to diametric strain, ϵ_d, by

$$\epsilon_c = \frac{\Delta C}{C_0} = \frac{\Delta d}{d_0},$$

so that

$$\epsilon_c = \epsilon_d$$

where C_0 and d_0 are original specimen circumference and diameter, respectively.

(d) The compressive stress in the test specimen, σ, is calculated by dividing the compressive load P on the specimen by the initial cross-sectional area, A_0. Thus

$$\sigma = \frac{P}{A_0}$$

where in this test procedure, compressive stresses and strains are considered positive.

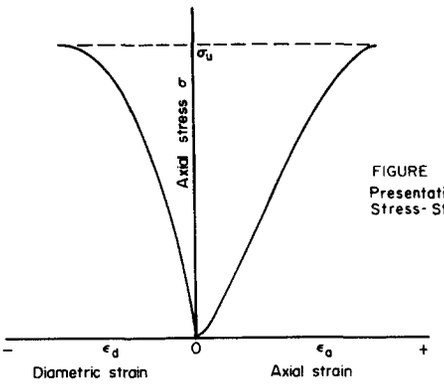


FIGURE 1.-Format for Graphical Presentation of Axial and Diametric Stress-Strain Curves.

Fig. 1. Format for graphical presentation of axial and diametric stress-strain curves.

(e) Fig. 1 illustrates typical plot of axial stress versus axial and diametric strains. These curves show typical behaviour of rock materials from zero stress up to ultimate strength, σ_u. The complete curves give the best description of the deformation behaviour of rocks having non-linear stress-strain behaviour at low and high stress levels.

(f) Axial Young's modulus, E (defined as the ratio of the axial stress change to axial strain produced by the stress change) of the specimen may be calculated using any one of several methods employed in accepted engineering practice. The most common methods, listed in Fig. 2, are as follows:

(1) Tangent Young's modulus, E_t, is measured at a stress level which is some fixed percentage of the ulti-

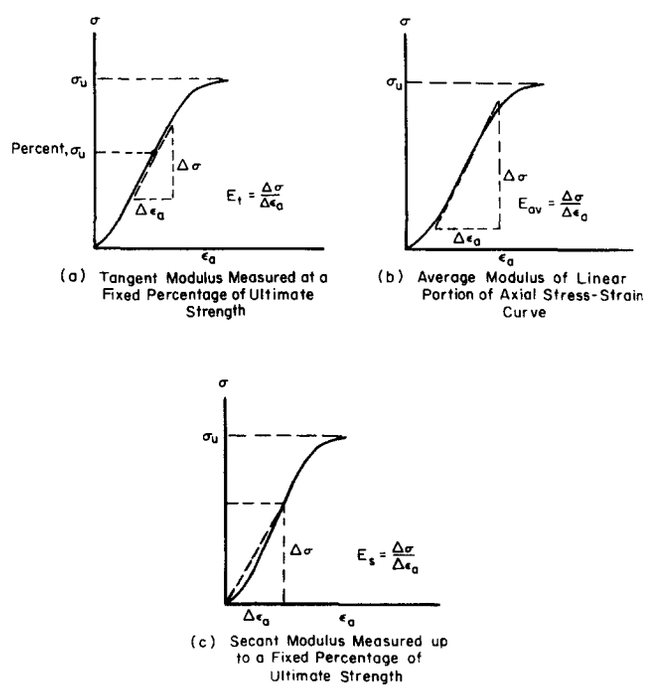


Fig. 2. Methods for calculating Young's modulus from axial stress-strain curve.

mate strength (Fig. 2a). It is generally taken at a stress level equal to 50% of the ultimate uniaxial compressive strength.

(2) Average Young's modulus, E_{av}, is determined from the average slopes of the more-or-less straight line portion of the axial stress-axial strain curve (Fig. 2b).

(3) Secant Young's modulus, E_s, is usually measured from zero stress to some fixed percentage of the ultimate strength (Fig. 2c), generally at 50%.

Axial Young's modulus E is expressed in units of stress i.e. pascal (Pa) but the most appropriate multiple is the gigapascal (GPa = 10^9 Pa).

(g) Poisson's ratio, ν, may be calculated from the equation

$$\nu = -\frac{\text{slope of axial stress–strain curve}}{\text{slope of diametric stress–strain curve}}$$

$$= -\frac{E}{\text{slope of diametric curve}}$$

where the slope of the diametric curve is calculated in the same manner for either of the three ways discussed for Young's modulus in paragraph 4(f). Note that Poisson's ratio in this equation has a positive value, since the slope of the diametric curve is negative by the conventions used in this procedure.

(h) The volumetric strain, ϵ_v, for a given stress level is calculated from the equation

$$\epsilon_v = \epsilon_a + 2\epsilon_d.$$

5. REPORTING OF RESULTS

The report should include the following:

(a) to (j)—See Part 1.

(k) Values of applied load, stress and strain as tabulated results or as recorded on a chart.

(l) Young's modulus and Poisson's ratio for each specimen in the sample, expressed to three significant figures, together with the average result for the sample.

(m) Method of determination of Young's modulus and at what axial stress level or levels determined.

(n) Sould it be necessary in some instances to test specimens that do not comply with the above specifications, these facts shall be noted in the test report.

REFERENCE

Standard method of test for elastic moduli of rock core specimens in uniaxial compression. *American Society for Testing and Materials*, ASTM Designation D 3148-72.

SINTEF

SINTEF Teknologi og samfunn
Berg og geoteknikk

Postadresse: 7465 Trondheim
Besøksadresse: Richard Birkelands vei 3
Telefon: 73 59 46 00
Telefaks: 73 59 71 36

Foretaksregisteret: NO 948 007 029 MVA

BA-LABORATORIENE VED SINTEF
www.sintef.no\ba-lab

PRØVINGSRAPPORT

OPPDRAGSGIVER

NGI

Postboks 3930 Ullevål Stadion
0806 Oslo

BESTILLING / OPPDRAGSGIVERS REF

PhD student Vidar Kveldsvik

OPPDRAGETS ART

E-Modul og Poissons ratio, UCS, Brasilianer Test, Lydhastighet og Romvekt

ARKIVKODE	GRADERING	FAGLIG ANSVARLIG	RAPPORTNUMMER
	Fortrolig		
ELEKTRONISK ARKIVKODE I:\Pro\222931 BERGLABORATORIER\20 Bergmek-lab\E-modul Oppdrag\NGI Vidar Kveldsvik		Trond Erik Larsen Trond Larsen	05058BM
PROSJEKTNR	DATO	SAKSBEARBEIDER	ANT SIDER/VEDLEGG
	2005-11-15	Trond Larsen,Simon A. Hagen og Ashut K. Taher	3

BERGTEKNISKE UNDERSØKELSER UTFØRT PÅ BOREKJERNER FRA ÅKERNESET

SINTEF Teknologi og samfunn, avd. Berg og geoteknikk mottok 2005-11-18 kjernemateriale med ø 45 mm, fordelt på 20 ulike bergartsprøver.

Det er foretatt følgende tester:

- E-Modul og Poissons ratio
- UCS
- Brasilianer Test
- Lydhastighet
- Romvekt

Alle testene er kjørt etter ISRM standarder

- Suggested methods for determinig uniaxial compressive strength and deformability of rock materials UCS, E-Modul og Poissons ratio
- Suggested method for determining indirect tensile strength by Brazil Test
- Suggested methods for determining sound velocity

Prøvingen er utført i perioden fra 2005-11-21 til 2005-12-08

Prøvingsresultatene refererer seg kun til de innsendte prøver.
Utdragsvis eller forkortet gjengivelse samt eventuell oversettelse av rapporten skal godkjennes av SINTEF.
Prøvematerialet kan kastes 1 måned etter rapportdato dersom ikke annet er avtalt skriftlig.

SINTEF

TESTRAPPORT

SINTEF Teknologi og samfunn

Berg og geoteknikk

Dato: 08.12.2005

ISRM Suggested Method for Determining Deformability of Rock Materials

Navn	Borehull[1]	Seksjon [m]	Bergart[2]	Kommentar om b.a.	Romvekt [kg/m³]	Hastighet [m/s]	Trykk σc [MPa]	Brudd vinkel [°]	Youngs modulus [GPa]	Poissons ratio	Vinkel mellom bor/fol	Brazil test [MPa]
1-1					2710	3793	129	21	49,9	0,13		16,3
1-2	KH-1Ø	69,4-70,0	GG		2722	3793	129	19	44,7	0,09	69	
1-3					2746	3818	109	18	42,8	0,15		
2-1	KH-1Ø	66,0-66,3	BG								56	12,0
3-1	KH-1Ø	58,7-60,8	BG		2842	3848	27	43	24,7	0,19	61-67	12,9
4-1					2777	4004	153	25	36,6	0,18		
4-2	KH-1Ø	30,2-31,55	DG		2761	4366	126	19	35,3	0,19	64	
4-3					2789	3700	173	16	38,5	0,14		
5-1					2614	4826	205	9	54,0	0,13		17,0
5-2	KH-1Ø	40,35-41,0	GG		2619	4909	160	10	54,5	0,16	ca 58	
5-3					2621	4912	189	13	45,9	0,15		
6-1					2744	2930	144	32	23,4	0,1		11,2
6-2	KH-1M	26,0-27,0	DG		2682	3254	162	25	28,1	0,1	77	
6-3					2674	3548	150	27	29,7	0,09		
7-1	KH-1M	23,5-24,0	BG								72	10,1
8-1					2821	4351	191	22	52,0	0,14		14,9
8-2	KH-1M	67,0-68,0	BG		2858	4285	136	15	63,9	0,16	78-90	
8-3					2747	4043	22	32				
9-1					2938	3063	127	23	32,5	0,1	83	12,3
9-2	KH-1M	37,0-38,0	BG		3083	2985	101	17	35,2	0,15		
10-1					2650	3681	205	26	44,1	0,12	Uregelm	16,4
10-2	KH-1M	48,0-48,8	GG		2647	3810	232	20	42,7	0,11	73	
10-3					2636	3710	215	22	44,7	0,1		
11-1				Mye biotitt	2691	3952	130	28	36,6	0,1		14,7
11-2	KH-1M	54,0-55,0	GG		2607	4317	169	22	39,7	0,1	Uregelm	
11-3					2712	4608	148	19	45,0	0,17	84-90	
12-1				Mye biotitt	2663	3617	155	17	31,5	0,1		15,6
12-2	KH-1M	30,2-31,0	GG		2633	3888	198	24	35,2	0,14	78	
12-3					2681	4042	158	19	37,3	0,12		

Navn	Borehull[1]	Seksjon [m]	Bergart[2]	Kommentar om b.a.	Romvekt [kg/m³]	Hastighet [m/s]	Trykk σc [MPa]	Brudd vinkel [°]	Youngs modulus [GPa]	Poissons ratio	Vinkel mellom bor/fold	Brazil test [MPa]
13-1				Mye biotitt	2702	4280	133	33	46,9	0,08		14,5
13-2	KH-1M	61,1-61,7	GG		2713	3761	139	14	28,0	0,08	80-85	
13-3												
14-2	KH-1M	28,5-29,0	BG		2745	3417	83	19			65	12,1
15-1				Mye biotitt	2776	4117	97	30	35,9	0,14		12,6
15-2	KH-1N	67,0-67,9	DG		2755	4225	127	15	35,5	0,1	48	
15-3					2623	4735	76	7				
16-1					2752	3691	137	16	49,1	0,16		14,1
16-2	KH-1N	65,0-66,0	BG	Mot diorittisk	2766	3813	167	35	48,7	0,15	40	
16-3					2761	3642	60	35	40,1	0,16		
17-1					2646	4257	216	5	46,3	0,13		14,1
17-2	KH-1N	36,1-37,0	GG	Mye biotitt	2642	4272	276	15	46,3	0,13	50-55	
17-3					2703	4044	128	25	42,0	0,1		
18-1					2746	3785	96	26	34,4	0,1		10,9
18-2	KH-1N	37,3-37,9	BG		2796	3698	74	5	33,6	0,13	57	
18-3					2734	3687	73	3	28,7	0,14		
19-1					2720	4236	183	23	42,4	0,12		15,9
19-2	KH-1N	49,0-49,9	BG	Mot diorittisk	2825	3864	153	20	33,5	0,15	65	
19-3					2822	3572	180	46	31,7	0,1		
20-1					2737	4086	118	30	48,8	0,18		14,5
20-2	KH-1N	73,35-73,9	GG		2710	3957	85	7	51,6	0,19	Småfoldet	
20-3					2739	4239	104	19	51,0	0,18		

[1] 1Ø og 1N er boret vertikalt. 1M er boret med 60° fall, dvs. omtrent vinkelrett på fjellsiden.

[2] GG = granittisk gneis, DG = diorittisk gneis og BG = biotittisk gneis