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Oskarshamn site investigation

Drill hole KSH02

Determining of porosity by water saturation and density by buoyancy technique

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March 2004

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Abstract

The density and porosity has been determined on 18 specimens (each divided in two pieces) from drill hole KSH02A. The specimens were sampled on three levels in the drill hole: 310, 610 and 800 m. The investigated rock type is mapped as Fine-grained dioritoid. The results for dry density varied between 2750 and 2820 kg/m^3, for wet density all the result were rounded to the nearest 10 kg/m^3 i.e. 2880 kg/m^3 and the results for porosity varied between 0.1 and 0.6%.

Contents

1 Introduction 7

2 Objective and scope 9

3 Equipment 11

4 Execution 13
4.1 Description of the samples 13
4.2 Testing 14

5 Results 15
5.1 Description and presentation of the specimen 15
5.2 Results for the entire test series 16
5.3 Discussion 18

References 19

Appendix 1 Results and pictures 21
Appendix 2 Calculations of density and porosity 29

1 Introduction

The purpose is to determine the porosity and the water saturated and dry density of the samples. The test programme follows the activity plan AP PS 400-03-090 (SKB internal controlling document).

The cores are sampled from borehole KSH02 in the Simpevarp area (Figure 1-1). It was sampled 19 September 2003 by Thomas Janson, Tyréns AB and Urban Åkesson, The Swedish National Testing and Research Institute (SP). Specimens were taken from three levels in the rock core: level 1 between 310 and 323 m, level 2 between 609 and 608 m, and level 3 between 791 and 804 mm. The samples were selected based on the preliminary core logging, and with the strategy to primarily investigate the properties of the dominant rock properties. The rock cores were transported by SP from Simpevarp and arrived to SP 20 September 2003. The testing was performed during January and February 2004.

Figure 1-1. *Map of Oskarshamn site.*

2 Objective and scope

The purpose of the testing is to determine the density and porosity of intact rock core. The parameters are used in the rock mechanical and thermal model which will be established for the candidate area selected for site investigations at Simpevarp.

The samples are from the borehole KSH02 in Simpevarp, which is a telescope borehole of SKB-standard type with a borehole depth of 1000 m. The samples in this report are taken at four different main levels.

3 Equipment

Following equipment has been used for the analyses:

- Thermometer (inv no 102080) for measurement of water temperature. Calibrated 2003-01-07. Uncertainty of measurement ± 0.4°C.
- Scale (inv no 102291) for weight measurement. Calibrated 2003-08-12. Uncertainty of measurement ± 0.2 g.
- Heating chamber (inv no 102289) for drying the specimens. Calibrated 2003-08-22. Uncertainty of measurement ± 5°C.
- A covered plastic box filled with water for water saturation of the samples.
- A desiccators for cooling samples in

Uncertainty of method as expanded uncertainty with covering factor 2 (95% confidence interval):

Density	± 4 kg/m^3
Porosity	± 0.09%
Water absorption	± 0.05%

4 Execution

Determination of the porosity and density was made in accordance with SKB's method description SKB MD 160.002-version 1.9 (SKB internal controlling document); This includes determination of density in accordance to /ISRM 1979/, volume 16, number 2, water saturation by /EN 13755/ and in accordance to Activity plan AP PS 400-03-090 (SKB internal controlling document). The department of Building Technology and Mechanics (BM) at SP performed the test.

4.1 Description of the samples

From the Simpevarp area, Sweden was specimens sampled from four levels in drill hole KSH02. The drill hole starts at a depth of 100 m. Level 1 range between 310 and 323 m, level 2 between 609 and 608 m and level 3 between 791 and 804 m. Table 4-1 show the rock type and identification marks of the specimens.

Table 4-1. Rock type and identification marks (Rock-type classification according to Boremap).

Rock type	Identification	Sampling depth (Sec up)
Fine-grained dioritoid	KSH02A-90V-1	310.93
Fine-grained dioritoid	KSH02A-90V-2	311.20
Fine-grained dioritoid	KSH02A-90V-3	320.57
Fine-grained dioritoid	KSH02A-90V-4	320.94
Fine-grained dioritoid	KSH02A-90V-5	322.94
Fine-grained dioritoid	KSH02A-90V-6	323.13
Fine-grained dioritoid	KSH02A-90V-7	609.60
Fine-grained dioritoid	KSH02A-90V-8	609.68
Fine-grained dioritoid	KSH02A-90V-9	609.87
Fine-grained dioritoid	KSH02A-90V-10	610.04
Fine-grained dioritoid	KSH02A-90V-11	610.12
Fine-grained dioritoid	KSH02A-90V-12	607.85
Fine-grained dioritoid	KSH02A-90V-13	791.46
Fine-grained dioritoid	KSH02A-90V-14	792.74
Fine-grained dioritoid	KSH02A-90V-15	793.21
Fine-grained dioritoid	KSH02A-90V-16	794.43
Fine-grained dioritoid	KSH02A-90V-17	802.06
Fine-grained dioritoid	KSH02A-90V-18	804.43

4.2 Testing

The execution procedure followed the prescription in SKB MD 160.002-version 1.9 (SKB internal controlling document) and the following steps were performed:

Activity No	Activity
1	The specimens were cut according to the marks on the rock cores. Every specimen were cut in two pieces, marked A and B and about 25 mm thick each. The same specimens as were used to test Thermal properties: heat conductivity and heat capacity determined using the TPS method.
2	The specimens were water saturated in normal air pressure for at least seven days.
3	The specimens were weighted in tap water (see Appendix 2).
4	The specimens were surface dried with a towel and weighted.
5	The water saturated density was determined (see Appendix 2).
6	The samples were sent from SP Building and Mechanics to SP Fire Technology for measurement of thermal properties.
7	The samples were sent back from SP Fire Technology to SP Building and Mechanics.
8	The specimens were dried in a heating chamber at 105°C.
9	The specimens were transported to desiccators for cooling.
10	The dry density and porosity was determined (see Appendix 2).
11	The specimens were photographed in JPEG-format.

5 Results

The main results of the site investigation of KSH02 could be found in the database SICADA, FN161. The data from SICADA should be used for modelling.

Protocols, calculations and pictures can be finding in Appendix 1-2.

5.1 Description and presentation of the specimen

The temperature of water for water saturation was 20.5°C and the density of the water was 998 kg/m^3. The specimens were dried in 105°C for one week after water saturation.

Table 5-1. Summary of the results for porosity, dry density and wet density of the specimens from level 1 secup 310 m to 323 m. The result for each specimen is a mean value of sub sample A and B.

Specimen	Sampling depth, according to the marks on the drill-core boxes (Sec up) (m)	Porosity (%)	Dry density (kg/m3)	Wet density (kg/m3)
KSH02A-90V-1	310.93	0.2	2780	2780
KSH02A-90V-2	311.20	0.3	2770	2770
KSH02A-90V-3	320.57	0.4	2770	2770
KSH02A-90V-4	320.94	0.3	2780	2780
KSH02A-90V-5	322.94	0.3	2760	2760
KSH02A-90V-6	323.13	0.3	2770	2780
Mean value		0.3	2770	2770
Standard deviation		0.06	7	6

Table 5-2. Summary of the results for porosity, dry density and wet density of the specimens from level 2 secup 609 m to 610 m.

Specimen	Sampling depth, according to the marks on the drill-core boxes (Sec up) (m)	Porosity (%)	Dry density (kg/m3)	Wet density (kg/m3)
KSH02A-90V-7	609.60	0.4	2770	2770
KSH02A-90V-8	609.68	0.3	2760	2760
KSH02A-90V-9	609.87	0.3	2760	2760
KSH02A-90V-10	610.04	0.6	2760	2760
KSH02A-90V-11	610.12	0.4	2750	2760
KSH02A-90V-12	607.85	0.2	2800	2800
Mean value		0.4	2770	2770
Standard deviation		0.13	17	16

Table 5-3. Summary of the results for porosity, dry density and wet density of the specimens from level 4 secup 791 m to 804 m.

Specimen	Sampling depth, according to the marks on the drill-core boxes (Sec up) (m)	Porosity (%)	Dry density (kg/m3)	Wet density (kg/m3)
KSH02A-90V-13	791.46	0.2	2790	2790
KSH02A-90V-14	792.74	0.1	2810	2820
KSH02A-90V-15	793.21	0.2	2810	2820
KSH02A-90V-16	794.43	0.3	2770	2770
KSH02A-90V-17	802.06	0.2	2770	2770
KSH02A-90V-18	804.43	0.1	2780	2780
Mean value		0.2	2790	2790
Standard deviation		0.06	20	20

5.2 Results for the entire test series

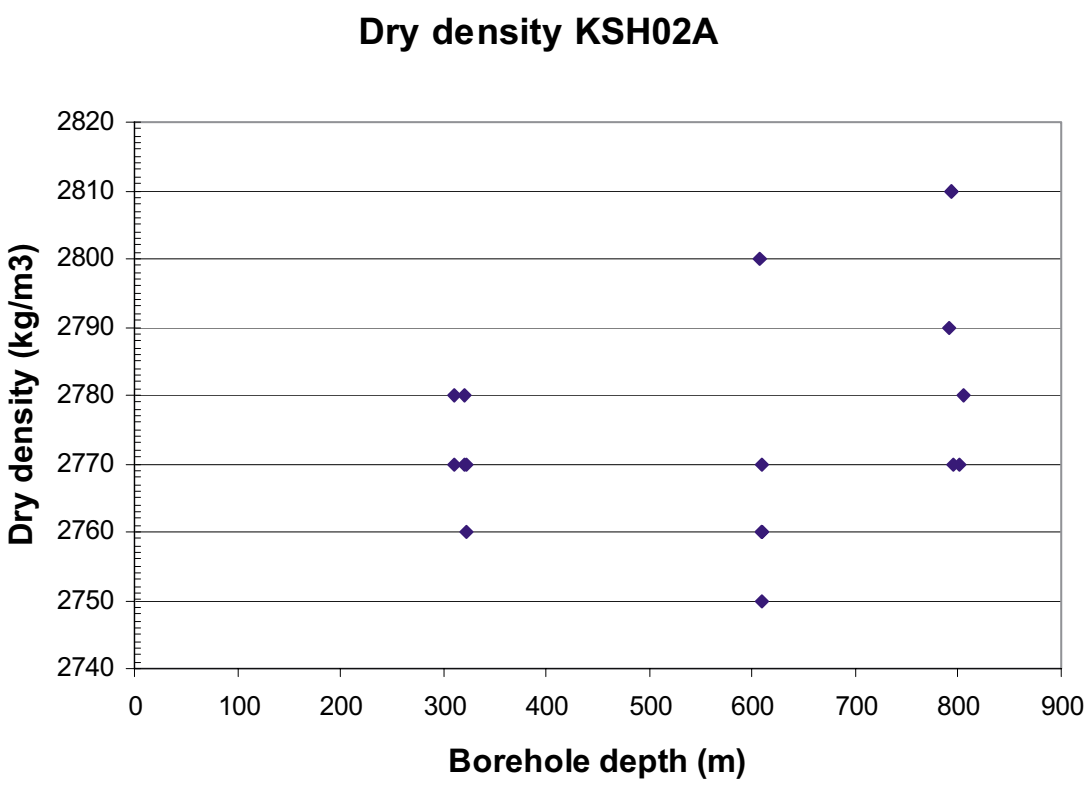

Figure 5-1. *Density (dry) versus depth which the samples are taken in the borehole.*

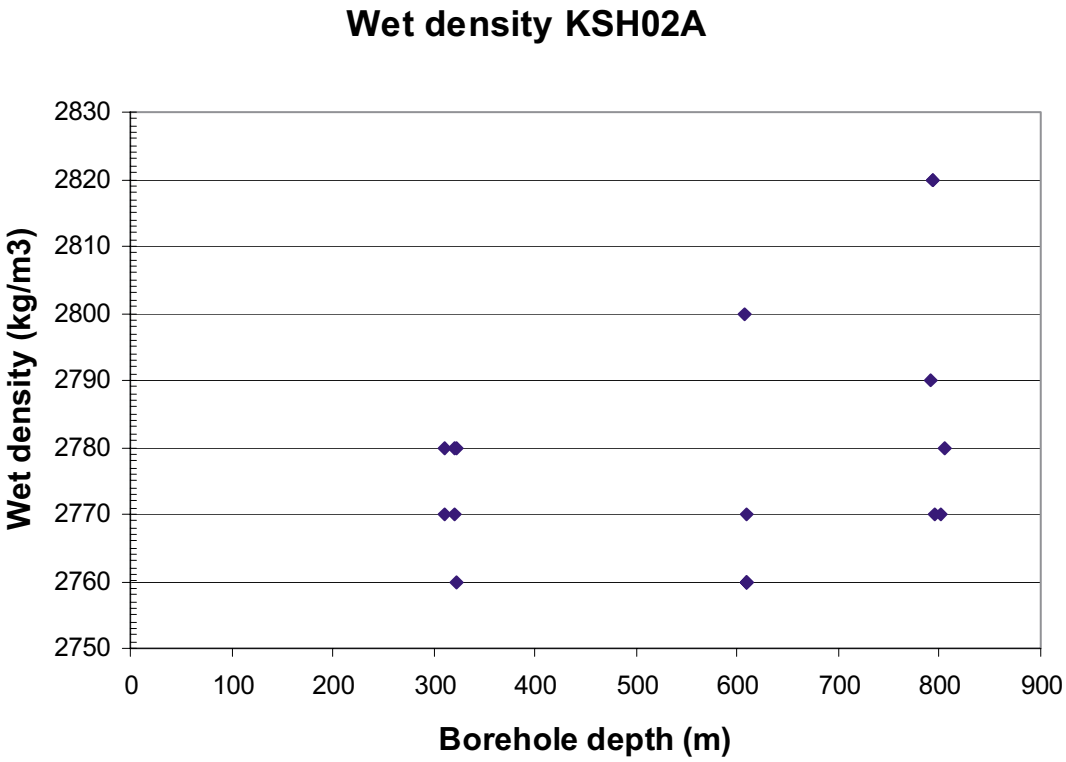

Figure 5-2. *Density (wet) versus depth which the samples are taken in the borehole.*

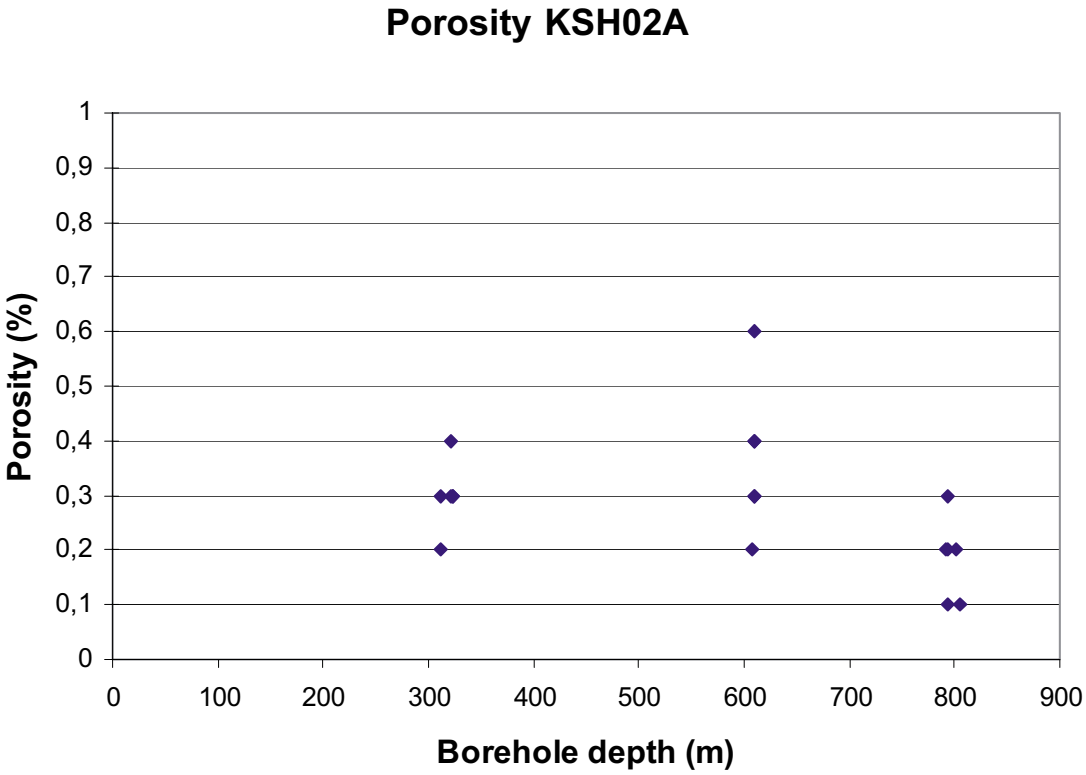

Figure 5-3. *Porosity versus depth which the samples are taken in the borehole.*

5.3 Discussion

Non deviations have been done.

References

EN 13755. Natural stone test methods – Determination of water absorption at atmospheric pressure.

ISRM, 1979. Suggested Method for Determining Water Content, Porosity, Density, Absorption and Related Properties and Swelling and Slake-durability Index Properties.

Appendix 1

Results and pictures

KSH02A: Density and porosity

Table 1: Level 1 310-323 m, Specimen KSH02A-090V-1 to KSH02A-090V-6

KSH02A-90V-1 (310,93) The dry density for specimen KSH02A-90V-1A was measured to be 2780 kg/m^3 and the porosity to 0,2 % and the dry density for specimen KSH02A-90V-1B was measured to be 2780 kg/m^3 and the porosity to 0,2 %.	**Fig. 1**. *Specimen KSH02A-90V-1.* 
KSH02A-90V-2 (311,20) The dry density for specimen KSH02A-90V-2A was measured to be 2770 kg/m^3 and the porosity to 0,2 % and the dry density for specimen KSH02A-90V-2B was measured to be 2770 kg/m^3 and the porosity to 0,4 %.	**Fig. 2.** *Specimen KSH02A-90V-2* 
KSH02A-90V-3 (320,57) The dry density for specimen KSH02A-90V-3A was measured to be 2770 kg/m^3 and the porosity to 0,4 % and the dry density for specimen KSH02A-90V-3B was measured to be 2770 kg/m^3 and the porosity to 0,3 %.	**Fig. 3**. *Specimen KSH02A-90V-3.* 

KSH02A-90V-4 (320,94) The dry density for specimen KSH02A-90V-4A was measured to be 2780 kg/m^3 and the porosity to 0,3 % and the dry density for specimen KSH02A-90V-4B was measured to be 2780 kg/m^3 and the porosity to 0,3 %.	**Fig. 4**. *Specimen KSH02A-90V-4.* 
KSH02A-90V-5 (322,94) The dry density for specimen KSH02A-90V-5A was measured to be 2760 kg/m^3 and the porosity to 0,3 % and the dry density for specimen KSH02A-90V-5B was measured to be 2760 kg/m^3 and the porosity to 0,3 %.	**Fig. 5**. *Specimen KSH02A-90V-5.* 
KSH02A-90V-6 (323,13) The dry density for specimen KSH02A-90V-6A was measured to be 2780 kg/m^3 and the porosity to 0,2 % and the dry density for specimen KSH02A-90V-6B was measured to be 2770 kg/m^3 and the porosity to 0,3 %.	**Fig. 6**. *Specimen KSH02A-90V-6.* 

Table 2: Level 2 609-608 m, Specimen KSH02A-090V-7 to KSH02A-090V-12

KSH02A-90V-7 (609,60) The dry density for specimen KSH02A-90V-7A was measured to be 2770 kg/m^3 and the porosity to 0,5 % and the dry density for specimen KSH02A-90V-7B was measured to be 2770 kg/m^3 and the porosity to 0,3 %.	**Fig. 7**. *Specimen KSH02A-90V-7.* 
KSH02A-90V-8 (609,68) The dry density for specimen KSH02A-90V-8A was measured to be 2760 kg/m^3 and the porosity to 0,3 % and the dry density for specimen KSH02A-90V-8B was measured to be 2760 kg/m^3 and the porosity to 0,3 %.	**Fig. 8**. *Specimen KSH02A-90V-8.* 
KSH02A-90V-9 (609,87) The dry density for specimen KSH02A-90V-9A was measured to be 2760 kg/m^3 and the porosity to 0,3 % and the dry density for specimen KSH02A-90V-9B was measured to be 2760 kg/m^3 and the porosity to 0,3 %.	**Fig. 9**. *Specimen KSH02A-90V-9.* 

KSH02A-90V-10 (610,04) The dry density for specimen KSH02A-90V-10A was measured to be 2750 kg/m^3 and the porosity to 0,5 % and the dry density for specimen KSH02A-90V-10B was measured to be 2760 kg/m^3 and the porosity to 0,6 %.	**Fig. 10**. *Specimen KSH02A-90V-10.* 
KSH02A-90V-11 (610,12) The dry density for specimen KSH02A-90V-11A was measured to be 2760 kg/m^3 and the porosity to 0,4 % and the dry density for specimen KSH02A-90V-11B was measured to be 2750 kg/m^3 and the porosity to 0,4 %.	**Fig. 11**. *Specimen KSH02A-90V-11.* 

Table 3: Level 3 791-804 m, Specimen KSH02A-090V-13 to KSH02A-090V-18

KSH02A-90V-12 (607,85) The dry density for specimen KSH02A-90V-12A was measured to be 2800 kg/m^3 and the porosity to 0,2 % and the dry density for specimen KSH02A-90V-12B was measured to be 2810 kg/m^3 and the porosity to 0,2 %.	**Fig. 12**. *Specimen KSH02A-90V-12.* 
KSH02A-90V-13 (791,46) The dry density for specimen KSH02A-90V-13A was measured to be 2790 kg/m^3 and the porosity to 0,2 % and the dry density for specimen KSH02A-90V-13B was measured to be 2790 kg/m^3 and the porosity to 0,3 %.	**Fig. 13**. *Specimen KSH02A-90V-13.* 
KSH02A-90V-14 (792,74) The dry density for specimen KSH02A-90V-14A was measured to be 2820 kg/m^3 and the porosity to 0,1 % and the dry density for specimen KSH02A-90V-14B was measured to be 2810 kg/m^3 and the porosity to 0,2 %.	**Fig. 14**. *Specimen KSH02A-90V-14.* 

KSH02A-90V-15 (793,21) The dry density for specimen KSH02A-90V-15A was measured to be 2810 kg/m^3 and the porosity to 0,2 % and the dry density for specimen KSH02A-90V-15B was measured to be 2820 kg/m^3 and the porosity to 0,2 %.	**Fig. 15**. *Specimen KSH02A-90V-15.* 
KSH02A-90V-16 (794,43) The dry density for specimen KSH02A-90V-16A was measured to be 2770 kg/m^3 and the porosity to 0,3 % and the dry density for specimen KSH02A-90V-16B was measured to be 2770 kg/m^3 and the porosity to 0,3 %.	**Fig. 16**. *Specimen KSH02A-90V-16.* 
KSH02A-90V-17 (802,06) The dry density for specimen KSH02A-90V-17A was measured to be 2770 kg/m^3 and the porosity to 0,2 % and the dry density for specimen KSH02A-90V-17B was measured to be 2780 kg/m^3 and the porosity to 0,2 %.	**Fig. 17**. *Specimen KSH02A-90V-17.* 

KSH02A-90V-18 (804,43) The dry density for specimen KSH02A-90V-18A was measured to be 2790 kg/m^3 and the porosity to 0,1 % and the dry density for specimen KSH02A-90V-18B was measured to be 2780 kg/m^3 and the porosity to 0,1 %.	**Fig. 18**. *Specimen KSH02A-90V-18.* 

Appendix 2

Calculations of density and porosity

Densitet och porositet, SKB Geosigma

Uppdrags nr:KSHO2A
Metod: EN 13755, ISRM (1973), avsnitt 3 samt SKB MD 160.002 version 1.0
Provad av:Lej
Datum: 2004-01-19-02-16

	Provmärkning:	Vikt i vatten, Msub (g)	Yttor vikt, Msat (g)	Torr vikt, Ms (g)	Bulk volume, V (cm3)	Pore volume, Vv (cm3)	Porosity, n (%)	medel por	Dry density, ρd (g/cm3)	medel dens	Wet density (g/cm3)	medel våt dens
1	1A	91,89	143,33	143,22	51,54	0,11	0,21	0,2	2,779	2,78	2,781	2,78
2	1B	92,63	144,47	144,36	51,94	0,11	0,21		2,779		2,782	
3	2A	92,24	144,13	144,03	51,99	0,10	0,19	0,3	2,770	2,77	2,772	2,77
4	2B	91,62	143,15	142,97	51,63	0,18	0,35		2,769		2,773	
5	3A	91,3	142,58	142,39	51,38	0,19	0,37	0,4	2,771	2,77	2,775	2,77
6	3B	90,43	141,37	141,2	51,04	0,17	0,33		2,767		2,770	
7	4A	91,61	142,83	142,68	51,32	0,15	0,29	0,3	2,780	2,78	2,783	2,78
8	4B	91,5	142,76	142,62	51,36	0,14	0,27		2,777		2,780	
9	5A	90,37	141,37	141,2	51,10	0,17	0,33	0,3	2,763	2,76	2,767	2,76
10	5B	90,41	141,58	141,45	51,27	0,13	0,25		2,759		2,762	
11	6A	91,07	142,13	142,01	51,16	0,12	0,24	0,3	2,776	2,77	2,778	2,78
12	6B	91,12	142,28	142,14	51,26	0,14	0,27		2,773		2,776	
13	7A	91,21	142,6	142,34	51,49	0,26	0,51	0,4	2,765	2,77	2,770	2,77
14	7B	91,3	142,55	142,4	51,35	0,15	0,29		2,773		2,776	
15	8A	90,5	141,76	141,6	51,36	0,16	0,31	0,3	2,757	2,76	2,760	2,76
16	8B	90,16	141,25	141,09	51,19	0,16	0,31		2,756		2,759	
17	9A	89,38	139,87	139,74	50,59	0,13	0,26	0,3	2,762	2,76	2,765	2,76
18	9B	90,59	141,81	141,65	51,32	0,16	0,31		2,760		2,763	
19	10A	90,78	142,23	141,96	51,55	0,27	0,52	0,6	2,754	2,76	2,759	2,76
20	10B	90,98	142,4	142,08	51,52	0,32	0,62		2,758		2,764	
21	11A	90,82	142,16	141,95	51,44	0,21	0,41	0,4	2,760	2,75	2,764	2,76
22	11B	90,27	141,58	141,36	51,41	0,22	0,43		2,750		2,754	
23	12A	92,03	143,03	142,91	51,10	0,12	0,24	0,2	2,797	2,80	2,799	2,80
24	12B	89,94	139,57	139,48	49,72	0,09	0,18		2,805		2,807	
25	13A	92,47	143,92	143,8	51,55	0,12	0,23	0,2	2,790	2,79	2,792	2,79
26	13B	92,54	144,08	143,95	51,64	0,13	0,25		2,788		2,790	
27	14A	94,17	145,8	145,73	51,73	0,07	0,14	0,1	2,817	2,81	2,819	2,82
28	14B	93,87	145,49	145,41	51,72	0,08	0,15		2,812		2,813	
29	15A	94,03	145,74	145,65	51,81	0,09	0,17	0,2	2,811	2,81	2,813	2,82
30	15B	94,32	146,04	145,95	51,82	0,09	0,17		2,817		2,818	
31	16A	91,99	143,78	143,63	51,89	0,15	0,29	0,3	2,768	2,77	2,771	2,77
32	16B	91,15	142,51	142,37	51,46	0,14	0,27		2,767		2,769	
33	17A	91,08	142,47	142,39	51,49	0,08	0,16	0,2	2,766	2,77	2,767	2,77
34	17b	91,65	142,92	142,84	51,37	0,08	0,16		2,781		2,782	
35	18a	92,37	143,87	143,82	51,60	0,05	0,10	0,1	2,787	2,78	2,788	2,78

Vattnets temperatur (°C):	20,5
Vattnets desitet (°C)	0,9981

Våg, inv.nr:102291
Termometer, inv.nr:102080

medel 1-6	0,28	2,77	2,77
stdavv 1-6	0,058942199	0,006713315	0,00652154
medel 7-12	0,37	2,77	2,77
stdavv 7-12	0,132524484	0,017217321	0,016428716
medel 13-18	0,19	2,79	2,79
stdavv 13-18	0,061765045	0,020185457	0,019902522