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Äspö Hard Rock Laboratory

DECOVALEX

Drill hole KF0066A01 and KF0069A01

Determination of porosity by water
saturation and density by buoyancy
technique

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September 2005

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This report concerns a study which was conducted for SKB. The conclusions and viewpoints presented in the report are those of the author(s) and do not necessarily coincide with those of the client.

Abstract

The density and porosity has been determined on 20 specimens from drill hole KF0066A01 and KF0069A01. The specimens were sampled on one level in both drill holes, 20-50 m. The investigated rock type is mapped as diorite. The results for dry density varied between 2660 and 2690 kg/m³, for wet density the results varied between 2660 and 2690 kg/m³ and the results for porosity varied between 0,2 and 0,4%.

Sammanfattning

Densiteten och porositeten har bestämts på 20 provkroppar från borrhål KF0066A01 och KF0069A01. Proverna togs från en nivå i borrhålen, 20-50 m. Den undersökta bergartstypen är karterad som diorit. Resultaten för den torra densiteten varierade mellan 2660 och 2690 kg/m³, för den våta densiteten varierade resultaten mellan 2660 och 2690 kg/m³ och resultaten för porositeten varierade mellan 0,2 och 0,4 %.

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1 Introduction

The purpose is to determine the porosity and the water saturated and dry density of the samples.

The cores are sampled from borehole KF0066A01 & KF0069A01 in the Äspö area (F-tunnel in the Äspö laboratory). Ann Bäckström, BBK, sampled them in March 2005. Specimens were taken from one level in two rock cores, from, KF0066A01 and KF0069A01, level 1 between 20 and 50 m. 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 from Äspö and arrived to SP in 19th of April and 14th of June. The testing was started in May 2005 and ended in June 2005.

2 Objective and scope

The purpose of the testing is to determine the density and porosity of intact rock cores. The parameters are used to investigate the influence of fluids with different salinities on uniaxial compression tests.

The samples are taken from borehole KF0066A01 and KF0069A01 in Äspö, with a depth of about 20 and 50 m. The cores were taken from horizontally oriented drill holes with a depth of approximately 450 m. Samples in this report are taken at one main level.

3 Equipment

Following equipment have been used for the analyses:

- Thermometer (inv no 102185) for measurement of water temperature. Calibrated 2005-02-04. Uncertainty of measurement $\pm 0,4$ °C .
- Scale (inv no 102291) for weight measurement. Calibrated in 2005-03-10. Uncertainty of measurement $\pm 0,2$ g.
- Heating chamber (inv no 102289) for drying the specimens. Calibrated 2004-08-31. Uncertainty of measurement ± 5 °C.
- A covered plastic box filled with water for water saturation of the samples.
- A dessicator for cooling samples in.

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

- Density ± 4 kg/m³
- Porosity $\pm 0,09$ %
- Water absorption $\pm 0,05$ %

4 Execution

Determination of the porosity and density was made in accordance with AP TDF84-05-011 and EN 1936, Natural stone test methods – Determination of real density and apparent density, and of total and open porosity.

4.1 Description of the samples

From the Äspö area, in Sweden, specimens were sampled from one level in drill holes KF0066A01 and KF0069A01. Level 1 range between 20 and 50 m. Table 4-1 shows the rock type and identification marks of the specimens.

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

Identification	Sampling depth (Seclow / Secup)	Rock type
KF0066A01 – S4	25,49-25,62	Diorite
KF0066A01 – T6	26,03-26,16	Diorite
KF0066A01 – D7	26,16-26,29	Diorite
KF0066A01 – S9	26,42-26,55	Diorite
KF0066A01 – S13	28,63-28,76	Diorite
KF0066A01 – D15	29,72-29,85	Diorite
KF0066A01 – F16	29,85-29,98	Diorite
KF0066A01 – S17	30,33-30,46	Diorite
KF0066A01 – T18	30,60-30,73	Diorite
KF0066A01 – D19	30,73-30,86	Diorite
KF0066A01 – F20	30,86-31,00	Diorite
KF0069A01 – S21	47,33-47,47	Diorite
KF0069A01 – D24	27,53-27,66	Diorite
KF0069A01 – T25	35,87-36,00	Diorite
KF0069A01 – D26	40,97-41,09	Diorite
KF0069A01 – F27	41,09-41,22	Diorite
KF0069A01 – F28	42,02-42,15	Diorite
KF0069A01 – T29	45,58-45,71	Diorite
KF0069A01 – F30	46,36-46,49	Diorite
KF0069A01 - T31	27,80-27,95	Diorite

4.2 Testing

The execution procedure followed the prescription in AP TDF84-05-011 and EN 1936. , see Table 4-2.

Table 4-2

Activity No	Activity
1	The specimens were cut according to the marks on the rock cores. The same specimens were used to test uniaxial compression test..
2	The specimens were dried in a heating chamber at 105° C.
3	The specimens were transported to a dessicator for cooling.
4	The specimens were saturated under a pressure of 20 mbar.
5	The specimens were weighted in distilled water, specimens saturated in formation water were weighted in formationwater.
6	The specimens were surface dried with a towel and weighted.
7	The water saturated density was determined.
8	The dry density and porosity were determined.
9	The samples were sent from SP Building and Mechanics, Building Material (house 11) to SP Building and Mechanics, solid mechanics and structures (house 12) for uniaxial compression tests
10	The samples were sent back from house 12 to house 11.

5 Results

A detailed presentation of the results can be found in Appendix 1.

5.1 Description and presentation of the specimen

The temperature of liquid for saturation was 21,8 °C and the density of the water was 998 kg/m³ and the density of formation water was 100 kg/m³. Table 5-1 shows the identification marks, porosity, dry and wet density.

Table 5-1. Summary of the results for porosity, dry density and wet density of the specimens from level 1, seclow 20 to 50 m. for testing of the dry samples for uniaxial compression tests.

Specimen	Sampling depth, according to the marks on the drill-core boxes (Seclow) (m)	Porosity (%)	Dry density (kg/m ³)	Wet density (kg/m ³)
KF0066A01 – T6	26,03-26,16	0,4	2660	2660
KF0066A01 – T18	30,60-30,73	0,4	2670	2680
KF0069A01 – T25	35,87-36,00	0,4	2680	2690
KF0069A01 – T29	45,58-45,71	0,2	2680	2680
KF0069A01 - T31	27,80-27,95	0,2	2680	2680
Mean value		0,3	2680	2680
Standard deviation		0,1	10	9

Table 5-2. Summary of the results for porosity, dry density and wet density of the specimens from level 1, seclow 20 to 50 m tested on specimens saturated in distilled water.

Specimen	Sampling depth, according to the marks on the drill-core boxes (Seclow) (m)	Porosity (%)	Dry density (kg/m ³)	Wet density (kg/m ³)
KF0066A01 – D7	26,16-26,29	0,4	2660	2660
KF0066A01 – D15	29,72-29,85	0,3	2670	2670
KF0066A01 – D19	30,73-30,86	0,4	2680	2680
KF0069A01 – D24	27,53-27,66	0,3	2670	2670
KF0069A01 – D26	40,97-41,09	0,2	2660	2660
Mean value		0,3	2670	2670
Standard deviation		0,1	8	9

Table 5-3. Summary of the results for porosity, dry density and wet density of the specimens from level 1, seclow 20 to 50 m tested on specimens saturated in formation water.

Specimen	Sampling depth, according to the marks on the drill-core boxes (Seclow) (m)	Porosity (%)	Dry density (kg/m ³)	Wet density (kg/m ³)
KF0066A01 – F16	29,85-29,98	0,4	2680	2680
KF0066A01 – F20	30,86-31,00	0,4	2680	2680
KF0069A01 – F27	41,09-41,22	0,2	2680	2680
KF0069A01 – F28	42,02-42,15	0,2	2690	2690
KF0069A01 – F30	46,36-46,49	0,2	2690	2690
Mean value		0,3	2680	2680
Standard deviation		0,1	7	6

Table 5-4. Summary of the results for porosity, dry density and wet density of the specimens from level 1, seclow 20 to 50 m tested on specimens saturated in saline water (10% NaCl solution)

Specimen	Sampling depth, according to the marks on the drill-core boxes (Seclow) (m)	Porosity (%)	Dry density (kg/m ³)	Wet density (kg/m ³)
KF0066A01 – S4	25,49-25,62	0,4	2660	2670
KF0066A01 – S9	26,42-26,55	0,3	2660	2660
KF0066A01 – S13	28,63-28,76	0,4	2670	2680
KF0066A01 – S17	30,33-30,46	0,4	2670	2680
KF0069A01 – S21	47,33-47,47	0,4	2670	2670
Mean value		0,4	2670	2670
Standard deviation		0,0	6	6

5.2 Discussion

Determination of porosity and density was made in accordance with SKB's method description SKB MD 160.002: Determining the density and porosity of intact rock. Version 2.0 (SKB internal controlling document), with following exception, instead of following ISRM 1979, volume 16, number 2 and water saturation by EN 13755 the test procedure followed the method descriptions in EN 1936.

Deviations from EN 1936: specimens that were tested in formation water and saline water were also saturated in the same liquids, and specimens in formation water were also weighted in formation water, this procedure is an exception from the method descriptions. The tests were otherwise performed in accordance with the method descriptions in EN 1936.

References

EN 1936, Natural stone test methods – Determination of real density and apparent density, and of total and open porosity

Appendices

Appendix 1 Results.

Report No.:	P502239
Drill hole:	KF0066A01 & KF0069A01
Method:	EN 1936

Test samples, see next page

Preparation of test samples:	Date	Signature
Sawing:	2005-05-10	Lej
Start sample saturating	2005-06-27	Lej
Weighing of surface dry water saturated samples	2005-06-30	Lej
Drying, start:	2005-05-19	Lej
Weighing of dry samples	2005-05-23	Lej

Equipment	Equipment No.	Date of calibration
Scale	102291	10-mar
Heating chamber	102289	2004-08-31
Thermometer	102185	2005-02-04
Vacuum pump	102312	2004-10-15

Miscellaneous	
Deviations during testing	

Registrerat tryck under provning (mbar)	20
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Appendix 1
KF066A01 KF069A01

Density and porosity

Method: SS:EN 1936
Drill hole: KF0066A01 & KF0069A01

Sample marking	Weight in water (g)	Surface dry weight (g)	Dry weight (g)	Bulk volume (cm ³)	Pore volume (cm ³)	Porosity (%)	Dry density (g/cm ³)	Wet density (g/cm ³)	From depth (m)	To depth (m)
6	433,50	693,45	692,52	260,47	0,93	0,4	2,66	2,66	26,03	26,16
18	433,74	691,22	690,12	258,00	1,10	0,4	2,67	2,68	30,60	30,73
25	429,71	683,80	682,91	254,60	0,89	0,4	2,68	2,69	35,87	36,00
29	435,39	693,14	692,75	258,27	0,39	0,2	2,68	2,68	45,58	45,71
31	436,41	695,29	694,79	259,40	0,50	0,2	2,68	2,68	27,80	27,95
D15	433,99	692,52	691,64	259,05	0,88	0,3	2,67	2,67	29,72	29,85
D19	433,75	691,26	690,29	258,03	0,97	0,4	2,68	2,68	30,73	30,86
D24	433,64	692,43	691,60	259,31	0,83	0,3	2,67	2,67	27,53	27,66
D26	431,94	691,71	691,19	260,29	0,52	0,2	2,66	2,66	40,97	41,09
D7	430,99	689,50	688,52	259,03	0,98	0,4	2,66	2,66	26,16	26,29
F16	432,25	691,41	690,42	258,08	0,99	0,4	2,68	2,68	29,85	29,98
F20	435,71	696,44	695,46	259,64	0,98	0,4	2,68	2,68	30,86	31,00
F27	433,14	693,00	692,47	258,77	0,53	0,2	2,68	2,68	41,09	41,22
F28	432,85	691,00	690,37	257,07	0,63	0,2	2,69	2,69	42,02	42,15
F30	432,89	690,37	689,83	256,40	0,54	0,2	2,69	2,69	46,36	46,49
S13	435,57	694,74	693,83	259,69	0,91	0,4	2,67	2,68	28,63	28,76
S17	433,10	690,29	689,21	257,71	1,08	0,4	2,67	2,68	30,33	30,46
S21	426,95	681,94	680,97	255,50	0,97	0,4	2,67	2,67	47,33	47,47
S4	434,42	694,38	693,40	260,48	0,98	0,4	2,66	2,67	25,49	25,62
S9	433,90	693,86	692,97	260,48	0,89	0,3	2,66	2,66	26,42	26,55

water temperature. (°C): 21,8
water density (g/cm³): 0,998

Formation water density (g/cm³): 1,0042