P-06-71

Oskarshamn site investigation

Borehole KLX12A

Determination of porosity by water saturation and density by buoyancy technique

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ISSN 1651-4416
SKB P-06-71

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Keywords: Rock mechanics, Petro-physics, Density, Porosity, AP PS 400-06-044.

Abstract

The density and porosity was determined on 8 specimens (each divided into two pieces) from borehole KLX12A, Oskarshamn, Sweden. The specimens were sampled at one main level, measuring between 130–560 m in borehole length. The investigated rock types are mapped as Ävrö granite, diorite/gabbro and quartz monzodiorite. The results for the dry density varied between 2,700 and 3,050 kg/m^3, and for the wet density between 2,700 and 3,050 kg/m^3. Finally, the porosity results varied between 0.2 and 0.7%.

Sammanfattning

Densiteten och porositeten bestämdes på 8 provkroppar (varje provkropp delad i två delar) från borrhål KLX12A i Oskarshamn. Proverna togs från en nivå i borrhålet mellan 130–560 m borrhålslängd. De undersökta bergarterna är karterade som Ävrögranit, diorit/gabbro och kvartsmonzodiorit. Resultaten för torrdensiteten varierade mellan 2 700 och 3 050 kg/m^3 och för våtdensiteten mellan 2 700 och 3 050 kg/m^3. För porositeten, slutligen, varierade resultaten mellan 0,2 och 0,7 %.

Contents

1 Introduction

Specimens were sampled from the drill core of borehole KLX12A at the Oskarshamn site investigation area, Sweden, see Figure 1-1, for determination of the water saturated density, dry density and the porosity. Borehole KLX12A is a telescopic drilled borehole inclined c. 75° from the horizontal plane and with a total length of 602 m. The borehole section 0–102 m is percussion drilled, whereas the section 102–602 m is core drilled.

The sampling was based on the preliminary core logging with the strategy to primarily investigate the properties of the dominant rock types. The samples, which were collected by Björn Ljunggren, Tyrens AB in April 4, 2006, were transported to SP (Swedish National Testing and Research institute), department of Building and Mechanics, where they arrived in May 8, 2005. Testing commenced in May 2006 and was completed in August 2006, some of the samples were tested twice and these were completed in September 2006.

The commission was carried out in compliance with the controlling documents presented in Table 1-1. Activity Plan and Method Descriptions are SKB's (The Swedish Nuclear Fuel and waste Management Company) internal controlling documents, whereas SP-QD 13.1 is an SP internal Quality document.

Figure 1-1. *Location of all telescopic boreholes drilled up to March 2005 within and close to the Oskarshamn candidate area. The projection of each borehole on the horizontal plane at top of casing is also shown in the figure.*

Table 1-1. Controlling documents for performance of the activity.

Activity Plan	Number	Version
KLX12A. Bergmekaniska och termiska laboratoriebestämningar	AP PS 400-06-044	1.0
Method Description	**Number**	**Version**
Determining density and porosity of intact rock	SKB MD 160.002	2.0
Quality Plan		
SP-QD 13.1		

2 Objective and scope

The purpose of determining density and porosity of intact rock cores is to use these parameters in the rock mechanics and thermal site descriptive model, which will be established for the candidate area selected for site investigations at Oskarshamn.

The testing comprised of 8 rock samples from borehole KLX12A collected within the borehole interval 130–560 m.

3 Equipment

The following equipment was used for the density and porosity determinations:

- Thermometer (inv no 102185) for measurement of water temperature. Calibrated 2006-01-17. Measurement accuracy ± 0.4°C.
- Scale (inv no 102291) for weight measurement. Calibrated in 2005-03-10. Measurement accuracy ± 0.2 g.
- Heating chamber (inv no 102289) for drying the specimens. Calibrated 2006-01-17. Measurement accuracy ± 5°C.
- A covered plastic box filled with water for water saturation of the samples.
- A desiccator for cooling samples.

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, (SKB internal controlling document). This includes determination of density in accordance to ISRM 1979 /1/ and water saturation by EN 13755 /2/ and in compliance with Activity Plan AP PS 400-06-044 (internal controlling document of SKB). The department of Building Technology and Mechanics (BM) at SP performed the test.

4.1 Description of the specimens

The specimens from borehole KLX12A were sampled at levels ranging between approximately 130 and 560 m borehole length. Table 4-1 shows the identification mark, sampling level and rock type of each specimen.

Table 4-1. Identification mark, sampling level and rock type of each specimen (rock-type classification according to Boremap).

Identification	Sampling level (m borehole length, Adj seclow)	Rock type
KLX12A-90V-1	128.061	Ävrö granite (501044)
KLX12A-90V-2	222.060	Ävrö granite (501044)
KLX12A-90V-3	252.150	Ävrö granite (501044)
KLX12A-90V-4	306.059	Ävrö granite (501044)
KLX12A-90V-6	441.561	Diorite/Gabbro (501033)
KLX12A-90V-7	491.360	Diorite/Gabbro (501033)
KLX12A-90V-9	534.463	Quartz monzodiorite (501036)
KLX12A-90V-10	562.457	Quartz monzodiorite (501036)

4.2 Testing

The execution procedure followed the prescription in SKB MD 160.002, (SKB internal controlling document), see Table 4-2.

Table 4-2. The sequence of activities applied for execution of the commission.

Activity No	Activity
1	The specimens were cut according to the marks on the rock cores. Every specimen was cut into two pieces, marked A and B and about 25 mm thick each. The same specimens were used in a parallel activity to determine the thermal properties thermal conductivity and thermal diffusivity by applying the TPS method /3/.
2	The specimens were water saturated in normal air pressure for at least seven days.
3	The specimens were photographed in JPEG-format.
4	The specimens were weighed in tapwater. The temperature of the water was 25°C and the density 997 kg/m^3.
5	The specimens were surface dried with a towel and weighed.
6	The water saturated density was determined.
7	The samples were sent from SP Building Technology and Mechanics to SP Measurement technology for measurement of thermal properties.
8	The samples were sent from SP Measurement technology to SP Fire Technology for measurement of thermal properties /3/.
9	The samples were sent back from SP Fire Technology to SP Building Technology and Mechanics.
10	The specimens were dried in a heating chamber for six days at 105°C.
11	The specimens were transported to a desiccator for cooling.
12	The dry density and porosity were determined.

4.3 Nonconformities

The Activity Plan was followed without deviations.

A failure occurred during transportation of Sample 1 and 4 between SP Fire Technology and SP Building and Mechanics. Therefore were these two samples tested a second time.

An exception from the method was the statement of significant numbers in Appendix 1. The precision in the method for density gives only three significant digits the fourth digit given here is thus not significant. The precision in the method for porosity gives only one significant digit the second digit given here is thus not significant. It is important that this is kept in mind when the results are used for further calculation.

5 Results

The results of the porosity and density determinations of core samples from KLX12A are stored in SKB´s database SICADA, where they are traceable by the Activity Plan number.

Minutes and photos are presented in Appendix 1.

5.1 Results grouped according to rock type of the specimens

Table 5-1 summarize the results of the porosity and density determinations.

5.2 Results for the entire test series

Results for the entire test series are shown in the diagrams below. They are divided into three diagrams, see Figures 5-1 to 5-3, illustrating dry density, wet density and porosity.

Table 5-1. Summary of the results for porosity, dry density and wet density. The result for each specimen is a mean value of sub samples A and B.

Specimen	Sampling level (m borehole length), according to the marks on the drill-core boxes (Adj seclow)	Porosity (%)	Dry density (kg/m^3)	Wet density (kg/m^3)
KLX12A-90V-1	128.061	0.4	2,770	2,770
KLX12A-90V-2	222.060	0.6	2,700	2,700
KLX12A-90V-3	252.150	0.7	2,760	2,770
KLX12A-90V-4	306.059	0.7	2,740	2,750
KLX12A-90V-6	441.561	0.2	2,960	2,960
KLX12A-90V-7	491.360	0.2	3,050	3,050
KLX12A-90V-9	534.463	0.3	2,800	2,810
KLX12A-90V-10	562.457	0.2	2,810	2,820

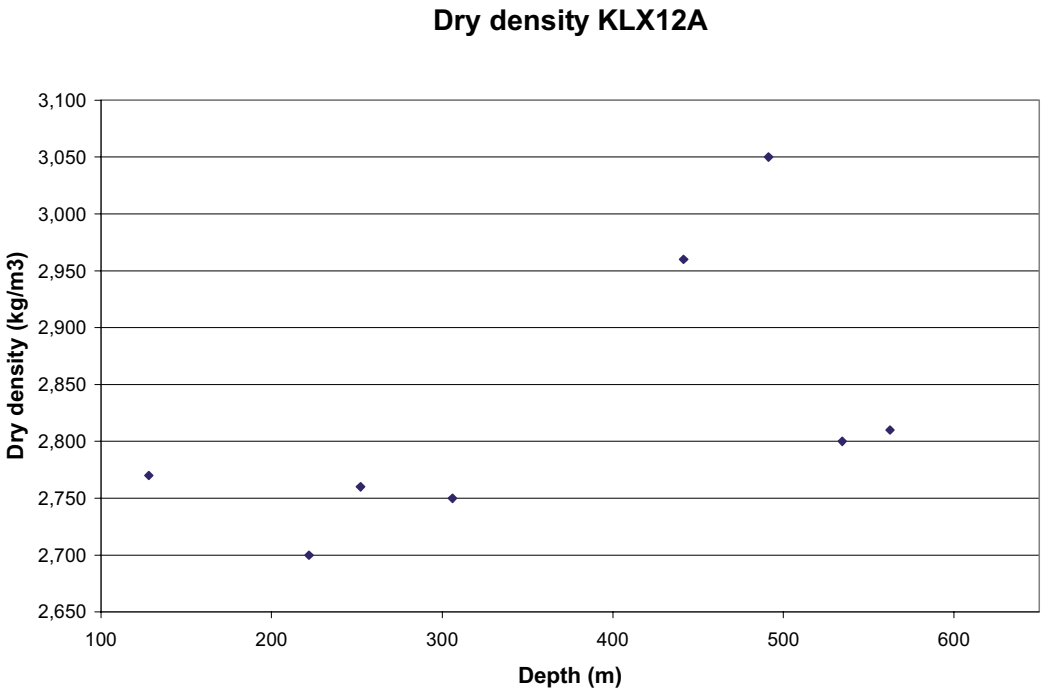

Figure 5-1. *Density (dry) versus sampling level (borehole length).*

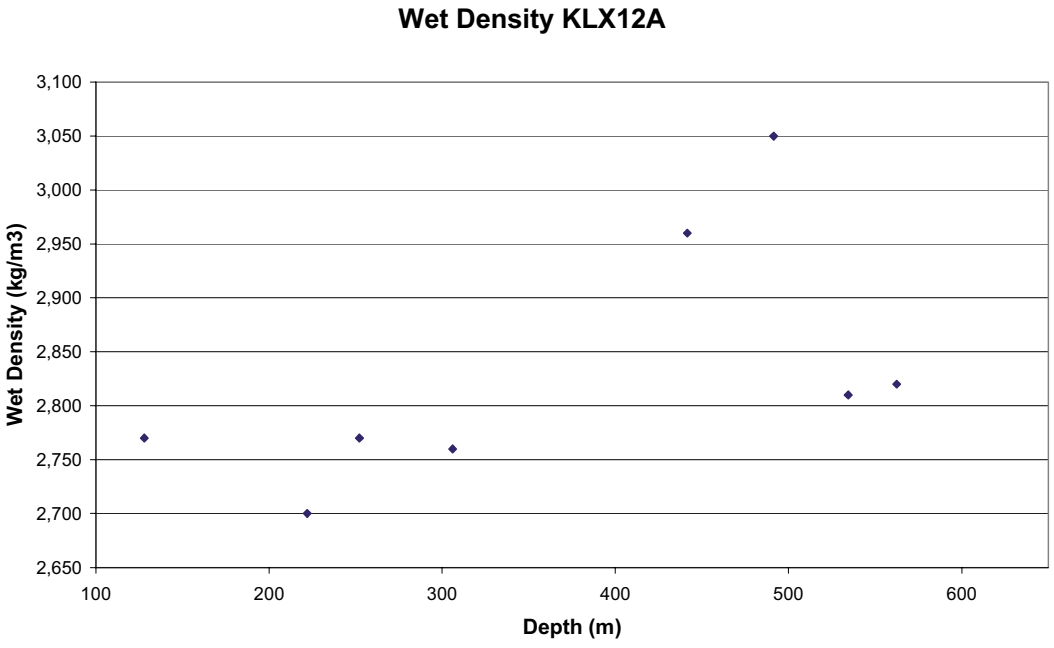

Figure 5-2. *Density (wet) versus sampling level (borehole length).*

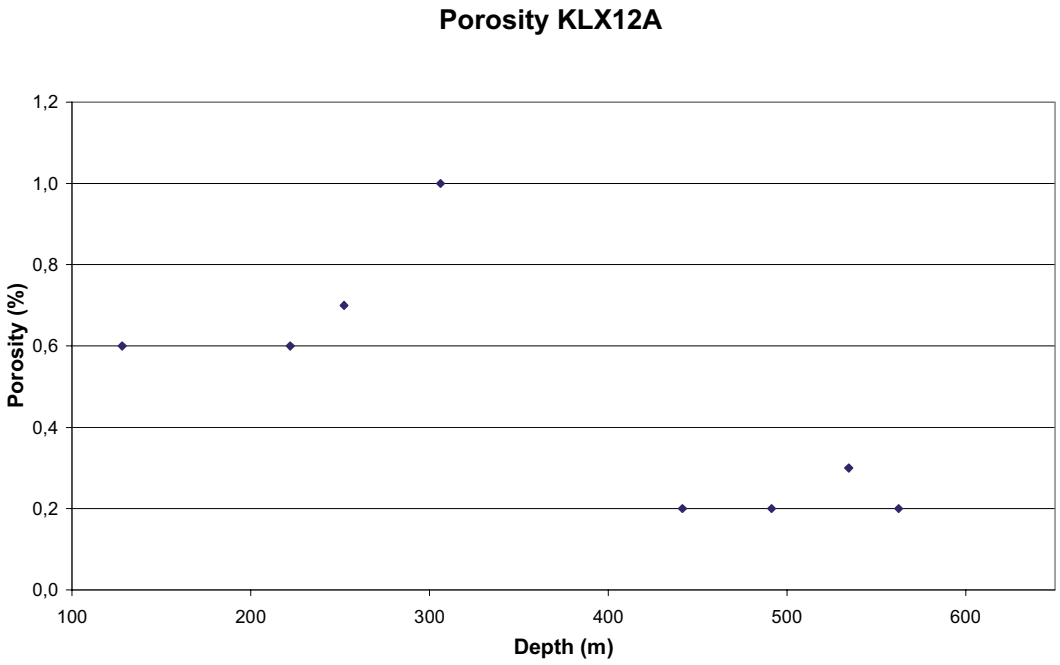

Figure 5-3. *Porosity versus sampling level (borehole length).*

References

/1/ **ISRM 1979.** Volume 16, Number 2.

/2/ **EN 13755.** Natural stone test methods – Determination of water absorption at atmospheric pressure.

/3/ **Adl-Zarrabi B, 2005.** Borehole KLX12A.Thermal conductivity and thermal diffusivity determined using the TPS method. SKB P-06-72, Svensk Kärnbränslehantering AB.

Appendix 1

Result minutes and photos

Table A-1. KLX12A, level 130–560 m. Specimens KLX12A-090V-1 to KLX12A-090V-10. Results in brackets are from the second testing.

KLX12A-90V-1 (128.061 m)

Dry density of specimen KLX12A-90V-1A 2,788 kg/m^3 and porosity 0.41%.

Dry density of specimen KLX12A-90V-1B 2,742 kg/m^3 and porosity 0.44%.

Figure A-1. *Specimens KLX12A-90V-1 A and B.*

KLX12A-90V-2 (222.060 m)

Dry density of specimen KLX12A-90V-2A 2,698 kg/m^3 and porosity 0.67%.

Dry density of specimen KLX12A-90V-2B 2,694 kg/m^3 and porosity 0.48%.

Figure A-2. *Specimens KLX12A-90V-2 A and B.*

KLX12A-90V-3 (252.150 m)

Dry density of specimen KLX12A-90V-3A 2,757 kg/m^3 and porosity 0.68%.

Dry density of specimen KLX12A-90V-3B 2,760 kg/m^3 and porosity 0.64%.

Figure A-3. *Specimens KLX12A-90V-3 A and B.*

KLX12A-90V-4 (306.059 m)

Dry density of specimen KLX12A-90V-4A 2,743 kg/m^3 and porosity 0.67%.

Dry density of specimen KLX12A-90V-4B 2,742 kg/m^3 and porosity 0.73%.

***Figure A-4**. Specimens KLX12A-90V-4 A and B.*

KLX12A-90V-6 (441.561 m)

Dry density of specimen KLX12A-90V-5A 2,964 kg/m^3 and porosity 0.16%.

Dry density of specimen KLX12A-90V-5B 2,957 kg/m^3 and porosity 0.15%.

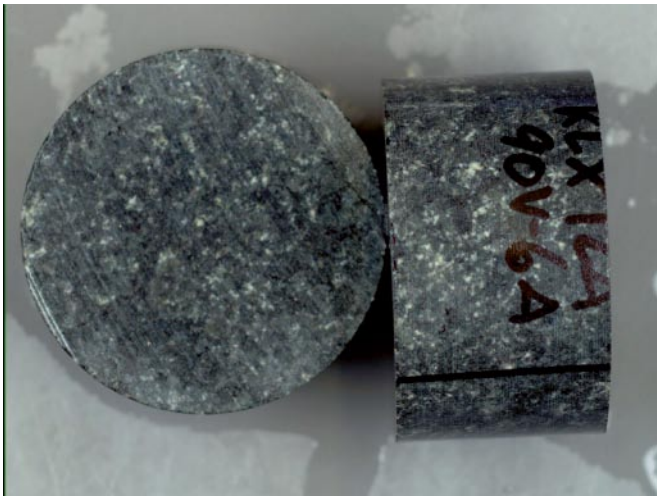

***Figure A-5.** Specimens KLX12A-90V-6 A and B.*

KLX12A-90V-7 (491.360 m)

Dry density of specimen KLX12A-90V-6A 3,049 kg/m^3 and porosity 0.18%.

Dry density of specimen KLX12A-90V-6B 3,048 kg/m^3 and porosity 0.15%.

***Figure A-6**. Specimens KLX12A-90V-7 A and B.*

KLX12A-90V-9 (534.463 m)

Dry density of specimen KLX12A-90V-7A 2,809 kg/m^3 and porosity 0.28%.

Dry density of specimen KLX12A-90V-7B 2,800 kg/m^3 and porosity 0.36%.

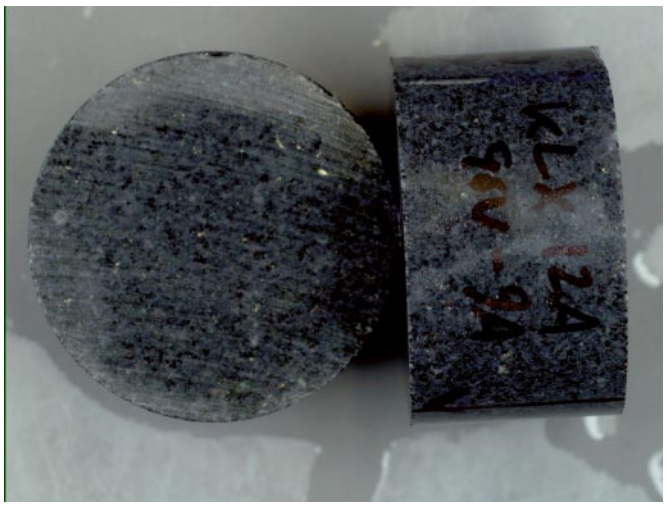

Figure A-7. *Specimens KLX12A-90V-9 A and B.*

KLX12A-90V-10 (562.457 m)

Dry density of specimen KLX12A-90V-8A 2,811 kg/m^3 and porosity 0.23%.

Dry density of specimen KLX12A-90V-8B 2,815 kg/m^3 and porosity 0.22%.

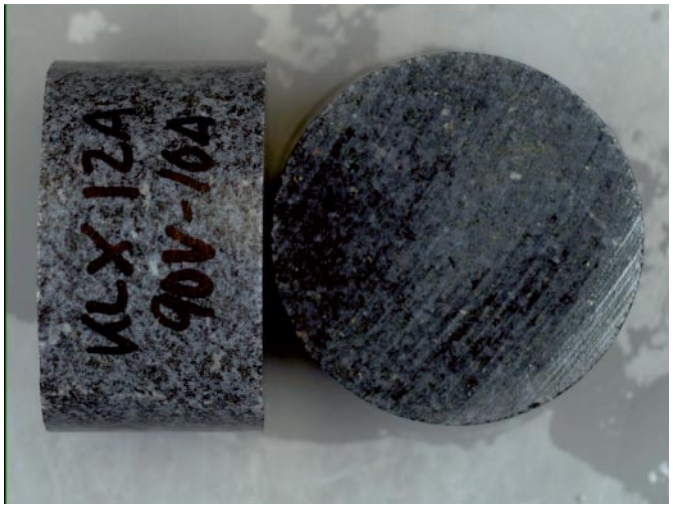

Figure A-8. *Specimens KLX12A-90V-10 A and B.*