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Oskarshamn site investigation

Borehole KLX16A

Determination of porosity by water saturation and density by buoyancy technique

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Abstract

The density and porosity was determined on 6 specimens (each divided into two pieces) from borehole KLX16A, Oskarshamn, Sweden. The specimens were sampled at borehole lengths measuring between 200–320 m. The investigated rock type is mapped as quartz monzodiorite (SKB rock code 501036). The results for the dry density varied between 2,780 and 2,830 kg/m^3, and for the wet density likewise between 2,780 and 2,830 kg/m^3. Finally, the porosity results varied between 0.2 and 0.4%.

Sammanfattning

Densiteten och porositeten bestämdes på 6 provkroppar (varje provkropp delad i två delar) från borrhål KLX16A i Oskarshamn. Proverna togs mellan borrhålslängden 200–320 m. Den undersökta bergarten är karterad som Kvartsmonzodiorit (SKB bergartskod 501036). Resultaten för torrdensiteten varierade mellan 2 780 och 2 830 kg/m^3 och för våtdensiteten likaså mellan 2 780 och 2 830 kg/m^3. För porositeten, slutligen, varierade resultaten mellan 0,2 och 0,4 %.

Contents

1 Introduction

This document reports performance and results of determination of porosity by water saturation and density by buoyancy technique within the site investigation programme att Oskarshamn, Sweden, /1/. The controlling documents for the activity are listed in Table 1-1. Both Activity Plan and Method Description are SKB's internal controlling documents, whereas the Quality Plan referred to in the table is an SP internal controlling document. The thermal properties conductivity and diffusivity of the specimens were determined within the scope of a parallel activity /2/.

Samples were collected from the drill core of borehole KLX16A located in the south-west of the Laxemar area, within the site investigation area at Oskarshamn, Sweden, see Figure 1-1. Borehole KLX16A is a conventional core drilled borehole with a total length of 430 m. The borehole is inclined by 65° against horizontal plane and strike 295°.

The samples were selected based on the preliminary core logging and with the strategy to primarily investigate the properties of the rock type quartz monzodiorite (501036). The samples, which were collected in Mars 26–27, 2007, were transported to SP (Swedish National Testing and Research institute), department of Building and Mechanics, where they arrived in April 13, 2007. Testing commenced in May 2007 and was completed in June 2007.

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

Activity Plan	**Number**	**Version**
KLX16A. Bergmekaniska och termiska laboratoriebestämningar	AP PS 400-07-041	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		

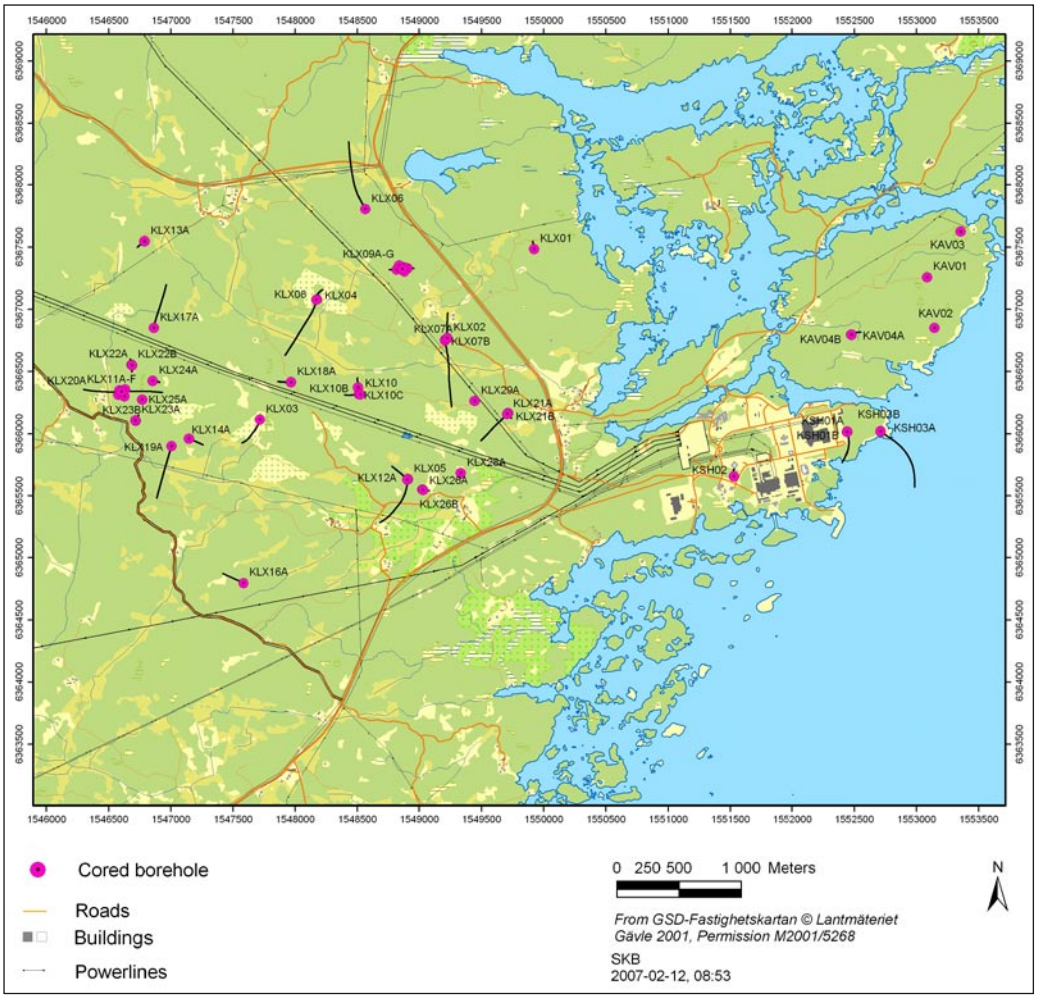

Figure 1-1. *Location of cored boreholes up to feb 2007.*

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 6 rock samples from borehole KLX16A collected within the borehole interval 200–320 m.

3 Equipment

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

- Thermometer (inv no 102185) for measurement of water temperature. Calibrated 2007-01-30. Measurement accuracy ± 0.4°C.
- Scale (inv no 102291) for weight measurement. Calibrated in 2007-03-22. Measurement accuracy ± 0.2 g.
- Heating chamber (inv no 102284) for drying the specimens. Calibrated 2007-01-30. 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 /3/ and water saturation by EN 13755 /4/ and in compliance with Activity Plan AP PS 400-07-041 (internal controlling document of SKB). The department of Building Technology and Mechanics (BM) at SP performed the tests.

4.1 Description of the specimens

The specimens from borehole KLX16A were sampled at levels ranging between 200 and 320 m borehole length. Table 4-1 shows the identification mark, sampling level and rock type of each specimen.

4.2 Testing

The temperature of the water used for water saturation was 17°C and the density was 999 kg/m^3. The specimens were dried in 105°C for seven days after water saturation. The execution procedure followed the prescription in SKB MD 160.002, see Table 4-2.

The present activity was performed parallel to another activity /2/, conducted by the department of Fire technology respectively Measurement technology at SP, and by which the thermal properties were determined. The following logistic sequence was applied for the three activities.

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

Identification	Sampling level (m borehole length, Adj seclow)	Rock type
KLX16A-90V-1	203.71	Quartz monzodiorite (501036)
KLX16A-90V-2	220.69	Quartz monzodiorite (501036)
KLX16A-90V-3	239.48	Quartz monzodiorite (501036)
KLX16A-90V-4	269.30	Quartz monzodiorite (501036)
KLX16A-90V-5	291.73	Quartz monzodiorite (501036)
KLX16A-90V-6	313.69	Quartz monzodiorite (501036)

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 and the calorimetric method /2/.
2	The specimens were water saturated in normal air pressure for at least seven days.
3	The specimens were weighed in tapwater. The temperature of the water was 17°C and the density 999 kg/m^3.
4	The specimens were surface dried with a towel and weighed.
5	The water saturated density was determined.
6	The samples were sent from SP Measurement technology to SP Fire Technology for measurement of thermal properties, TPS method /2/.
7	The samples were sent back from SP Fire Technology to SP Building Technology and Mechanics.
8	The specimens were dried in a heating chamber for seven days at 105°C.
9	The specimens were transported to a desiccator for cooling.
10	The dry density and porosity were determined.
11	The specimens were photographed in TIFF and JPEG-format.

4.3 Nonconformities

The Activity Plan was followed without deviations.

The tests were performed in accordance with the Method Description, however with the exception of the statement of significant numbers in Appendix 1. The precision in the method for density gives only three significant digits. The fourth digit given in Appendix 1 is thus not significant. The precision in the method for porosity provides only one significant digit and the second digit given in Appendix 1 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 KLX16A 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 of the specimens

Table 5-1 summarizes 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 of Quartz monzodiorite. The result for each specimen is a mean value of subsamples 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)
KLX16A-90V-1	203.71	0.4	2,780	2,780
KLX16A-90V-2	220.69	0.3	2,820	2,830
KLX16A-90V-3	239.48	0.3	2,820	2,830
KLX16A-90V-4	269.30	0.2	2,810	2,810
KLX16A-90V-5	291.73	0.2	2,830	2,830
KLX16A-90V-6	313.69	0.3	2,810	2,810
Mean value		0.3	2,810	2,820

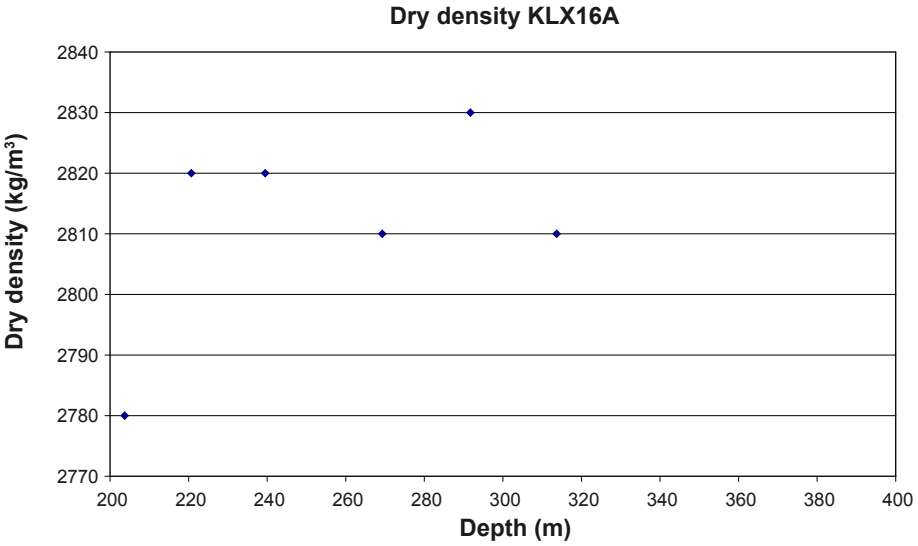

Figure 5-1. *Density (dry) versus sampling level (borehole length).*

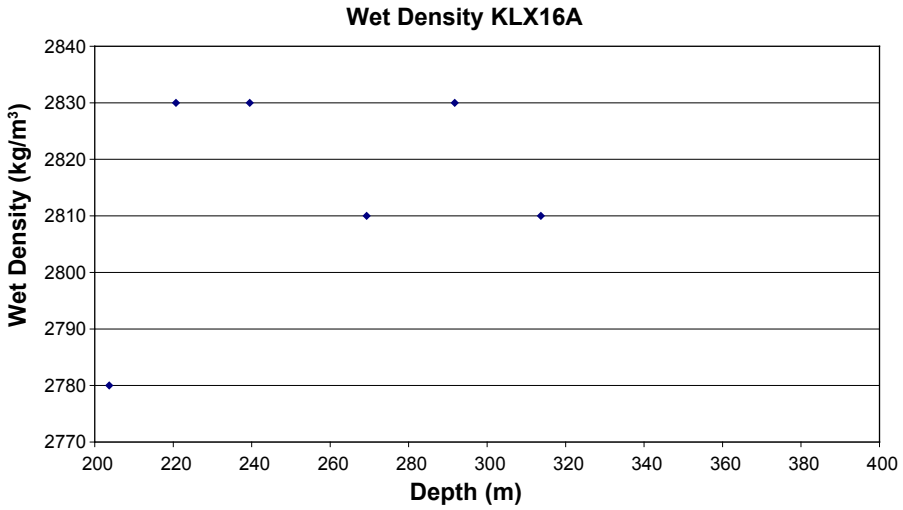

Figure 5-2. *Density (wet) versus sampling level (borehole length).*

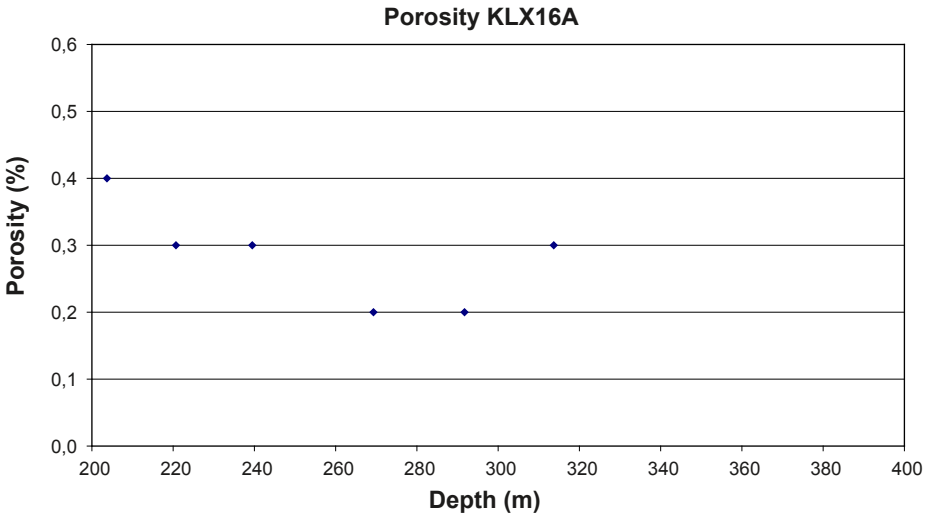

Figure 5-3. *Porosity versus sampling level (borehole length).*

References

/1/ **SKB, 2001.** Site investigations. Investigation methods and general execution programme. SKB TR-01-29, Svensk Kärnbränslehantering AB.

/2/ **Adl-Zarrabi B, 2007.** Borehole KLX16A. Thermal properties of rock using TPS method. SKB P-07-144, Svensk Kärnbränslehantering AB.

/3/ **ISRM 1979.** Volume 16, Number 2.

/4/ **EN 13755.** Natural stone test methods – Determination of water absorption at atmospheric pressure.

Result minutes and photos

Table A-1. KLX16A, level 200–320 m. Specimens KLX16A-90V-1 to KLX16A-90V-6.

KLX16A-90V-1 (203.71 m)

Dry density of specimen KLX16A-90V-1A 2,778 kg/m^3 and porosity 0.40%.

Dry density of specimen KLX16A-90V-1B 2,782 kg/m^3 and porosity 0.42%.

Figure A-1. *Specimens KLX16A-90V-1 A and B.*

KLX16A-90V-2 (220.69 m)

Dry density of specimen KLX16A-90V-2A 2,823 kg/m^3 and porosity 0.32%.

Dry density of specimen KLX16A-90V-2B 2,823 kg/m^3 and porosity 0.23%.

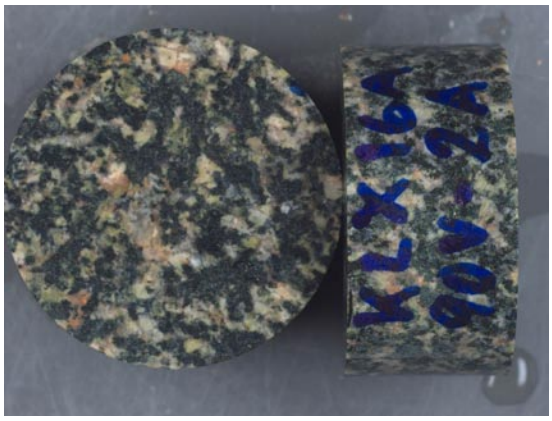

Figure A-2. *Specimens KLX16A-90V-2 A and B.*

KLX16A-90V-3 (239.48 m)

Dry density of specimen KLX16A-90V-3A 2,819 kg/m^3 and porosity 0.27%.

Dry density of specimen KLX16A-90V-3B 2,827 kg/m^3 and porosity 0.29%.

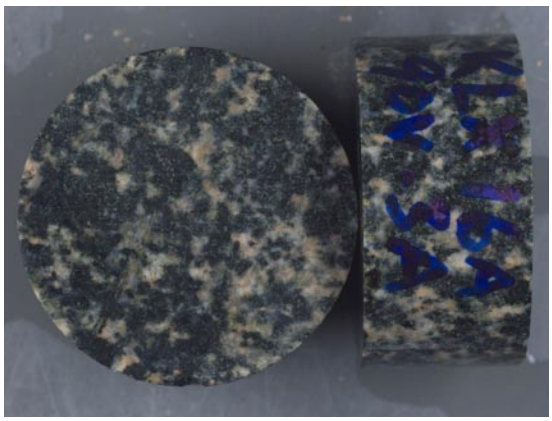

Figure A-3. *Specimens KLX16A-90V-3 A and B.*

KLX16A-90V-4 (269.30 m)

Dry density of specimen KLX16A-90V-4A 2,810 kg/m^3 and porosity 0.21%.

Dry density of specimen KLX16A-90V-4B 2,809 kg/m^3 and porosity 0.25%.

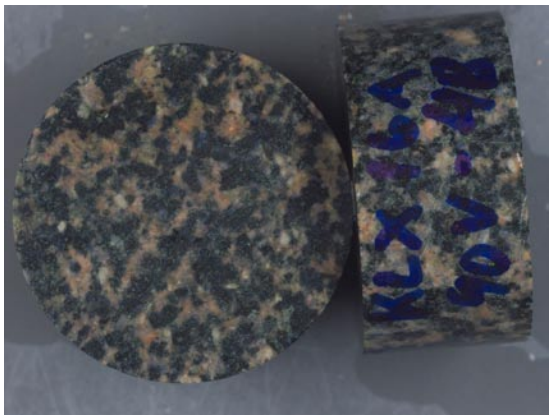

Figure A-4. *Specimens KLX16A-90V-4 A and B.*

KLX16A-90V-5 (291.73 m)

Dry density of specimen KLX16A-90V-5A 2,832 kg/m^3 and porosity 0.23%.

Dry density of specimen KLX16A-90V-5B 2,829 kg/m^3 and porosity 0.23%.

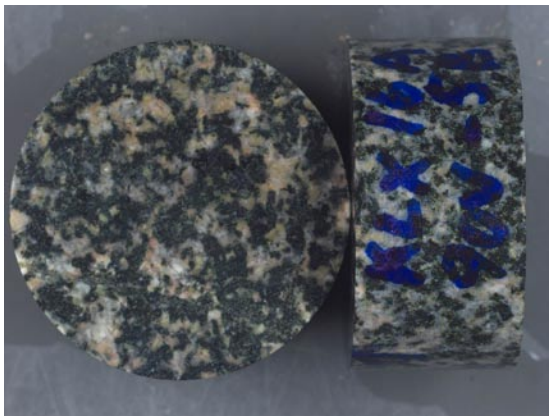

Figure A-5. *Specimens KLX16A-90V-5 A and B.*

KLX16A-90V-6 (313.69 m)

Dry density of specimen KLX16A-90V-6A 2,803 kg/m^3 and porosity 0.31%.

Dry density of specimen KLX16A-90V-6B 2,813 kg/m^3 and porosity 0.31%.

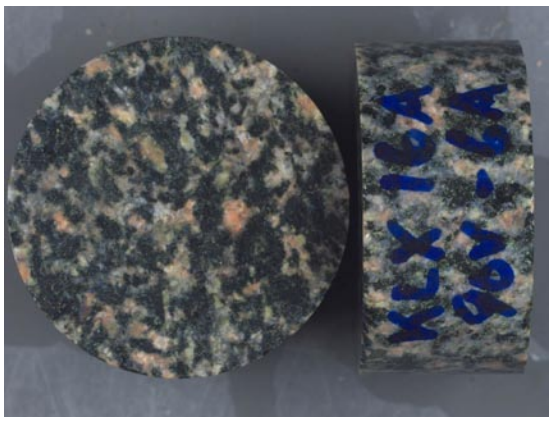

Figure A-6. *Specimens KLX16A-90V-6 A and B.*