P-05-124

Forsmark site investigation

Drill hole KFM06A

Determination of porosity by water saturation and density by buoyancy technique

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August 2005

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Abstract

The density and porosity have been determined on 6 rock specimens (each divided in two pieces) from drill hole KFM06A. The specimens were sampled within the interval 822–829 m borehole length. The investigated rock type is mapped as granite-aplitic (101058). The results for dry density varied between 2,640 and 2,660 kg/m^3, for wet density between 2,650 and 2,660 kg/m^{3,} and for porosity between 0.2 and 0.4%.

Sammanfattning

Densiteten och porositeten har bestämts på 6 borrkärnekroner (varje provkropp delad i två delar) från borrhål KFM06A. Proverna togs från intervallet 822–829 m borrhålslängd. Det aktuella borrhålsintervallet är karterat som granit-aplite (101058). Resultaten för den torra densiteten varierade mellan 2 640 och 2 660 kg/m^3, för den våta densiteten mellan 2 650 och 2 660 kg/m^3 och för porositeten mellan 0,2 och 0,4 %.

Contents

1 Introduction

Six drill core samples from borehole KFM06A in Forsmark, see Figure 1-1, were collected by Thomas Janson and Björn Lundgren, Tyréns AB, on November 29, 2004. The specimens were taken from the borehole interval 822–829 m borehole length. The samples were selected based on the preliminary core logging, and with the strategy to primarily investigate the properties of the dominant rock types. The rock cores were transported from Forsmark and arrived at SP in February 2005. The testing was started the same month and ended in April 2005.

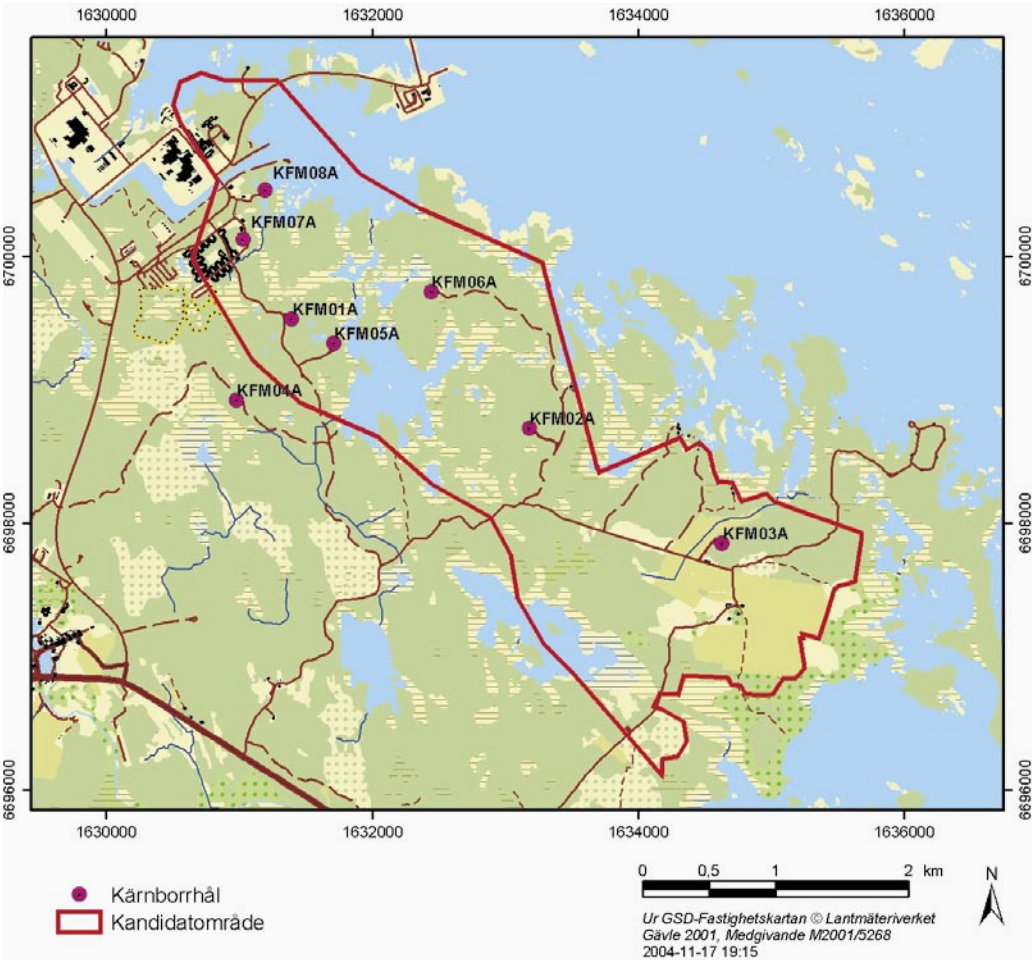

Figure 1-1. *Location of drill hole KFM06A at the Forsmark site.*

2 Objective and scope

The purpose of the testing was to determine the density and porosity of intact rock cores. The parameters are used in the rock mechanics and thermal site descriptive model, which will be established for the candidate area selected for site investigations at Forsmark.

The samples are collected from the telescopic borehole KFM06A in Forsmark, which is inclined c. 60° from the horizontal plane, and has a drilling length of c. 1,000 m. Drill cores were produced in the borehole interval c. 100–1,000 m.

3 Equipment

The following equipment has been employed for the analyses:

- Thermometer (inv no 102185) for measurement of water temperature. Calibrated 2005-02-04. Uncertainty of measurement ± 0.4°C.
- Scale (inv no 102291) for weight measurement. Calibrated in 2004-03-10. Uncertainty of measurement ± 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 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 compliance to ISRM 1979, volume 16, number 2, water saturation by EN 13755 and in accordance to Activity Plan AP PF 400-04-121 (internal controlling document of SKB). The department of Building Technology and Mechanics (BM) at SP performed the test.

4.1 Description of the samples

Specimens were sampled from one level in drill hole KFM06A ranging between 822 and 829 m borehole length. 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 (Adj Seclow)	Rock type
KFM06A-90V-1	822.81	Granite-aplitic (101058)
KFM06A-90V-2	822.87	Granite-aplitic (101058)
KFM06A-90V-3	822.96	Granite-aplitic (101058)
KFM06A-90V-4	828.89	Granite-aplitic (101058)
KFM06A-90V-5	828.96	Granite-aplitic (101058)
KFM06A-90V-6	829.02	Granite-aplitic (101058)

4.2 Testing

The execution procedure followed the prescription in SKB MD 160.002.
The general step-by-step sequence for performing the activity is presented in Table 4-2.

Table 4-2. The sequence for 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 in two pieces, marked A and B and about 25 mm thick each. The same specimens were used to test thermal properties: heat conductivity and heat capacity determing using the TPS method.
2	The specimens were photographed in JPEG-format.
3	The specimens were water saturated in normal air pressure for at least seven days.
4	The specimens were weighed in tapwater (See Appendix 2).
5	The specimens were surface dried with a towel and weighed.
6	The water saturated density was determined (See Appendix 2). The temperature of water for water saturation was 18.5ºC and the density of the water was 999 kg/m^3.
7	The samples were returned SP Building and Mechanics to SP Fire Technology for measurement of thermal properties.
8	The samples were sent back from SP Fire Technology to SP Building and Mechanics.
9	The specimens were dried in a heating chamber at 105℃.
10	The specimens were transported to a desiccator for cooling.
11	The dry density and porosity were determined, (See Appendix 2).

4.3 Nonconformities

The tests were performed in accordance with the method descriptions and the activity plan without deviations.

5 Results

Data resulting from this activity are stored in the SKB database SICADA, where they are traceable by the activity plan number. Protocols, calculations and photos are presented in Appendices 1–2.

5.1 Summary of results

A summary of the results of the porosity and density determinations is presented in Table 5-1, as well as in Figures 5-1, 5-2 and 5-3 below.

Table 5-1. Summary of the results for porosity, dry density and wet density of the specimens at sampling depth, adj seclow 822 to 829 m borehole length. The result for each specimen is a mean value of sub-samples A and B.

Specimen	Sampling depth (borehole length), according to the marks on the drill-core boxes (adj seclow) (m)	Porosity (%)	Dry density (kg/m³)	Wet density (kg/m³)
KFM06A-90V-1	822.81	0.2	2,650	2,650
KFM06A-90V-2	822.87	0.3	2,640	2,650
KFM06A-90V-3	822.96	0.3	2,650	2,650
KFM06A-90V-4	828.89	0.4	2,650	2,660
KFM06A-90V-5	828.96	0.4	2,650	2,660
KFM06A-90V-6	829.02	0.4	2,660	2,660
Mean value		0.3	2,650	2,650
Standard deviation		0.06	6	7

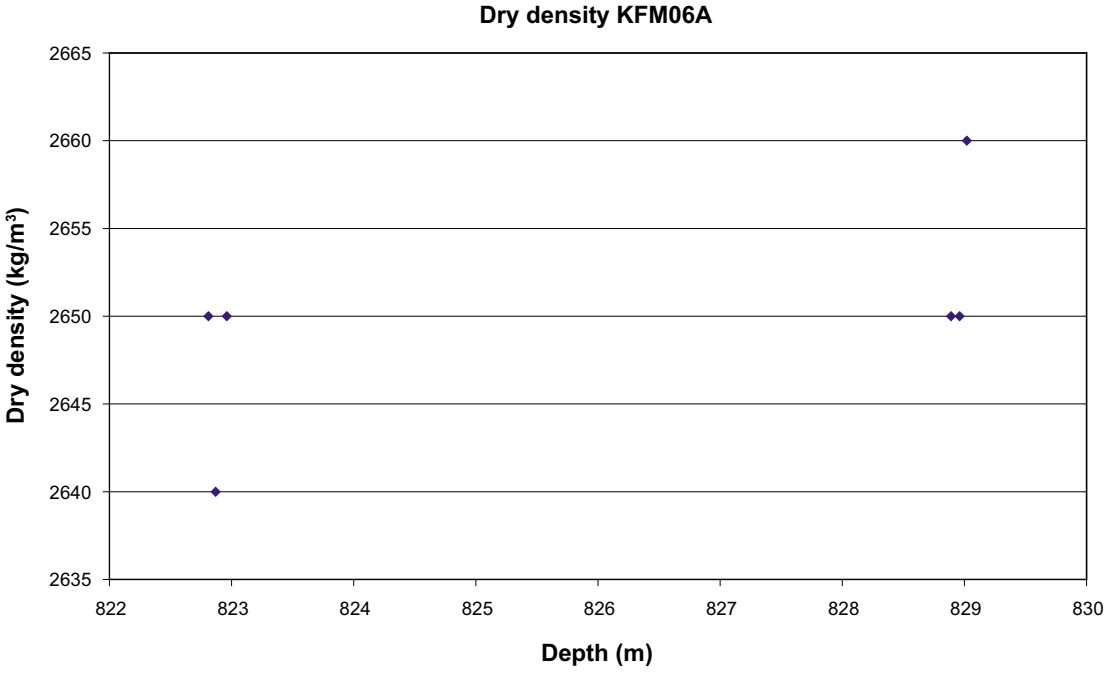

Figure 5-1. *Density (dry) versus borehole length.*

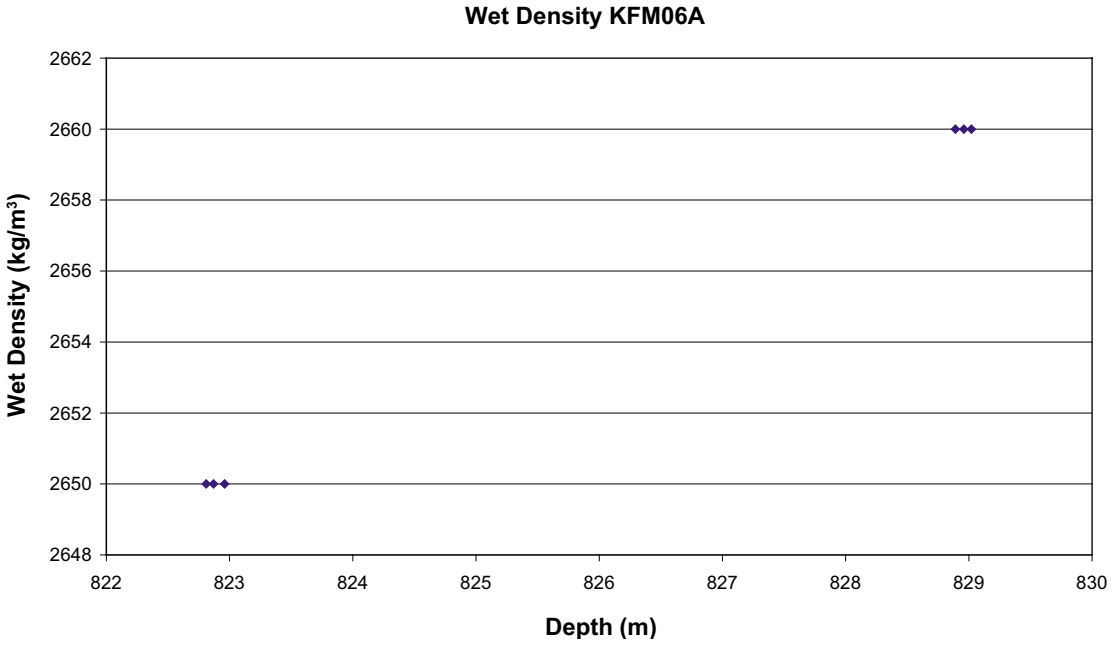

Figure 5-2. *Density (wet) versus borehole length.*

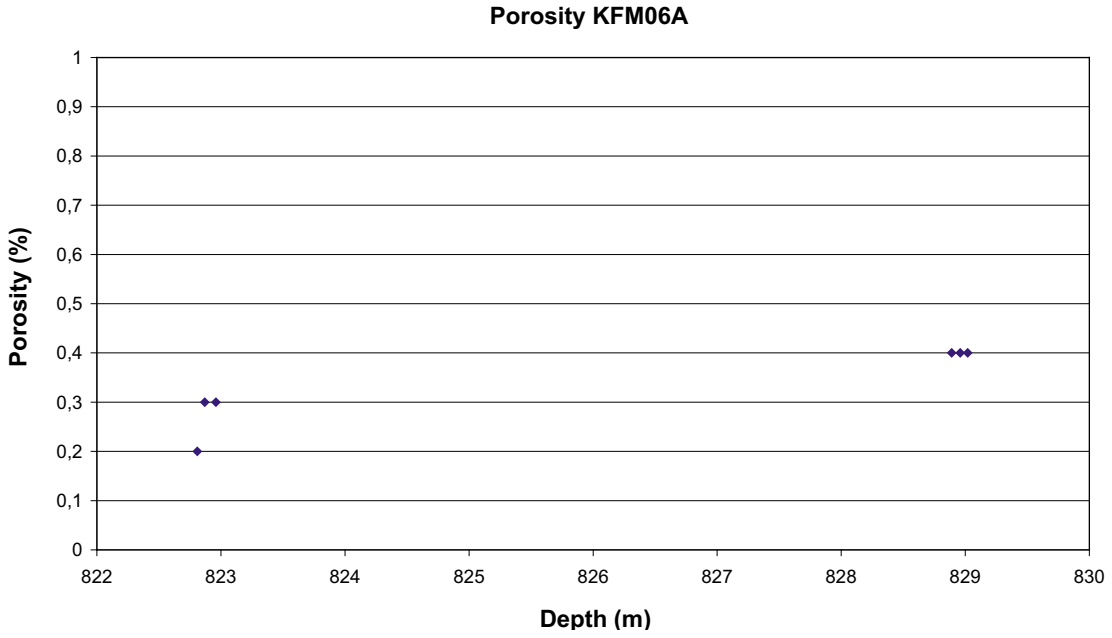

Figure 5-3. *Porosity versus borehole length.*

References

ISRM, 1979. Volume 16, Number 2.

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

Appendix 1

Results and pictures

KFM06A: Density and porosity

Table 1. Level 1 822–829 m, Specimen KFM06A-090V-1 to KFM06A-090V-6.

KFM06A-90V-1 (822.81)

The dry density for specimen KFM06A-90V-1A was measured to be 2,650 kg/m^3 and the porosity to 0.2% and the dry density for specimen KFM06A-90V-1B was measured to be 2,650 kg/m^3 and the porosity to 0.2%.

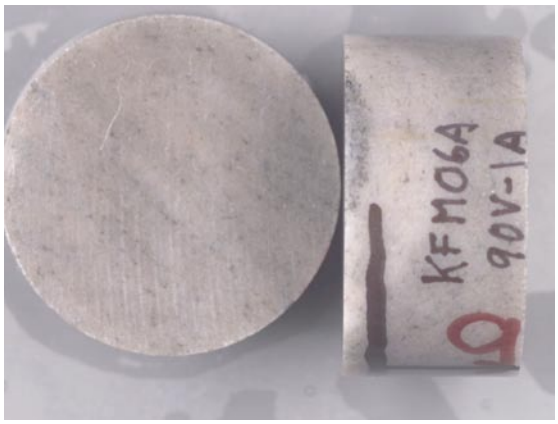

Figure A1-1. *Specimen KFM06A-90V-1.*

KFM06A -90V-2 (822.87)

The dry density for specimen KFM06A-90V-2A was measured to be 2,640 kg/m^3 and the porosity to 0.3% and the dry density for specimen KFM06A-90V-2B was measured to be 2,640 kg/m^3 and the porosity to 0.3%.

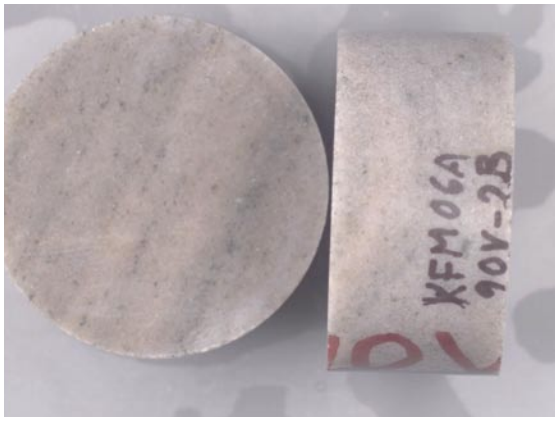

Figure A1-2. *Specimen KFM06A-90V-2.*

KFM06A -90V-3 (822.96)

The dry density for specimen KFM06A-90V-3A was measured to be 2650 kg/m^3 and the porosity to 0.3% and the dry density for specimen KFM06A -90V-3B was measured to be 2,650 kg/m^3 and the porosity to 0.3%.

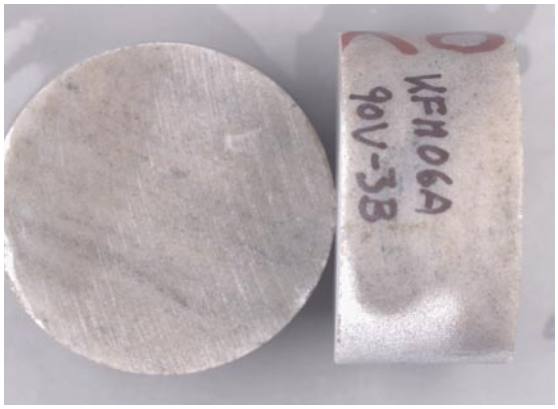

Figure A1-3. *Specimen KFM06A-90V-3.*

KFM06A -90V-4 (828.89)

The dry density for specimen KFM06A-90V-4A was measured to be 2,660 kg/m^3 and the porosity to 0.4% and the dry density for specimen KFM06A-90V-4B was measured to be 2,650 kg/m^3 and the porosity to 0.4%.

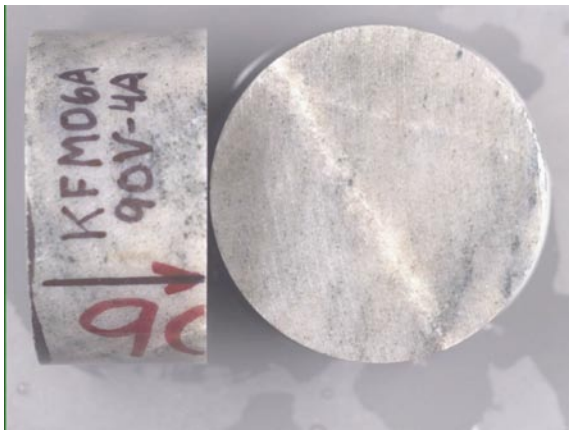

Figure A1-4. *Specimen KFM06A-90V-4.*

KFM06A -90V-5 (828.96)

The dry density for specimen KFM06A-90V-5A was measured to be 2,650 kg/m^3 and the porosity to 0.3% and the dry density for specimen KFM06A -90V-5B was measured to be 2,660 kg/m^3 and the porosity to 0.4%.

Figure A1-5. *Specimen KFM06A-90V-5.*

KFM06A -90V-6 (829.02)

The dry density for specimen KFM06A-90V-6A was measured to be 2,660 kg/m^3 and the porosity to 0.4% and the dry density for specimen KFM06A -90V-6B was measured to be 2,660 kg/m^3 and the porosity to 0.3%.

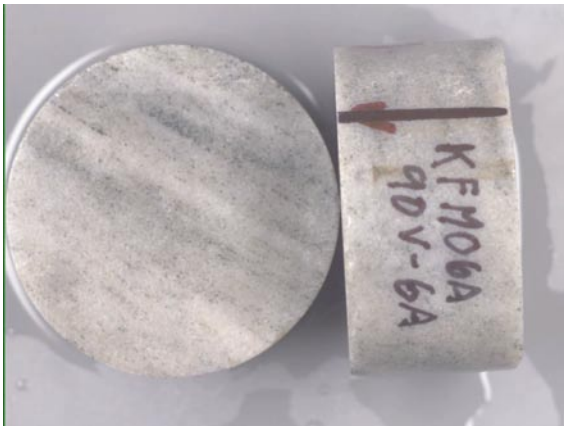

Figure A1-6. *Specimen KFM06A-90V-6.*