

**P-04-58**

## **Oskarshamn site investigation**

### **Drill hole KAV01**

#### **Determining of porosity by water saturation and density by buoyancy technique**

L Carlsson  
Swedish National Testing and Research Institute, SP

March 2004

**Svensk Kärnbränslehantering AB**

Swedish Nuclear Fuel  
and Waste Management Co  
Box 5864

SE-102 40 Stockholm Sweden

Tel 08-459 84 00  
+46 8 459 84 00

Fax 08-661 57 19  
+46 8 661 57 19



## **Oskarshamn site investigation**

### **Drill hole KAV01**

#### **Determining of porosity by water saturation and density by buoyancy technique**

L Carlsson

Swedish National Testing and Research Institute, SP

March 2004

*Keywords:* Rock mechanics, Petro physics, Density, Porosity.

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

A pdf version of this document can be downloaded from [www.skb.se](http://www.skb.se)

## Abstract

The density and porosity has been determined on 5 specimens (each divided in two pieces) from drill hole KAV01. The specimens were sampled on one level in the drill hole 500 m. The investigated rock type is mapped as Ävrö granite. The results for dry density varied between 2640 and 2680 kg/m<sup>3</sup>, for wet density all the results varied between 2640 and 2670 kg/m<sup>3</sup> and the results for porosity varied between 0.3 and 0.4%.

# Contents

<b>1</b>	<b>Introduction</b>	7
<b>2</b>	<b>Objective and scope</b>	9
<b>3</b>	<b>Equipment</b>	11
<b>4</b>	<b>Execution</b>	13
4.1	Description of the samples	13
4.2	Testing	14
<b>5</b>	<b>Results</b>	15
5.1	Description and presentation of the specimen	15
5.2	Results for the entire test series	16
5.3	Discussion	17
	<b>References</b>	19
	<b>Appendix 1</b> Results and pictures	21
	<b>Appendix 2</b> Calculations of density and porosity	23

# 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 400-03-091 (SKB internal controlling document).

The cores are sampled from borehole KAV01 in the Ävrö area (Figure 1-1). They were sampled 5 November 2003 by Thomas Janson, Tyréns AB and Urban Åkesson, Swedish National Testing and Research Institute (SP). Specimens were taken from one level in the rock core, 500 m. The rock cores were transported by SP from Simpevarp and arrived to SP 6 November 2003. The testing was performed during January and March 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 KAV01 in Ävrö, 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 2004-01-12. Uncertainty of measurement  $\pm 0.4^{\circ}\text{C}$  .
- Scale (inv no 102291) for weight measurement. Calibrated 2003-08-12. Uncertainty of measurement  $\pm 0.2$  g.
- Heating chamber (inv no 102289) for drying the specimens. Calibrated 2003-08-22. Uncertainty of measurement  $\pm 5^{\circ}\text{C}$ .
- 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	$\pm 4$ kg/m <sup>3</sup>
Porosity	$\pm 0.09\%$
Water absorption	$\pm 0.05\%$

## 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 400-03-091 (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 Ävrö area, Sweden was specimens sampled from one level in drill hole KAV01. The drill hole starts at a depth of 100 m. Level 1 range between 508 and 509 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)
Ävrö granite	KAV01-90V-7	508.25
Ävrö granite	KAV01-90V-8	508.32
Ävrö granite	KAV01-90V-9	509.09
Ävrö granite	KAV01-90V-10	509.14
Ävrö granite	KAV01-90V-11	509.20



## 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:

---

<b>Activity no</b>	<b>Activity</b>
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 a 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 KAV01 could be found in the database SICADA, FN178. 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 18.9°C and the density of the water was 998.5 kg/m<sup>3</sup>. 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 secup 508 to 509 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/m <sup>3</sup> )	Wet density (kg/m <sup>3</sup> )
KAV01-90V-7	508.25	0.4	2660	2660
KAV01-90V-8	508.32	0.3	2640	2640
KAV01-90V-9	509.09	0.3	2680	2680
KAV01-90V-10	509.14	0.4	2680	2680
KAV01-90V-11	509.20	0.4	2680	2690
Mean value	0.3	2670	2670	
Standard deviation	0.06	20	20	

## 5.2 Results for the entire test series

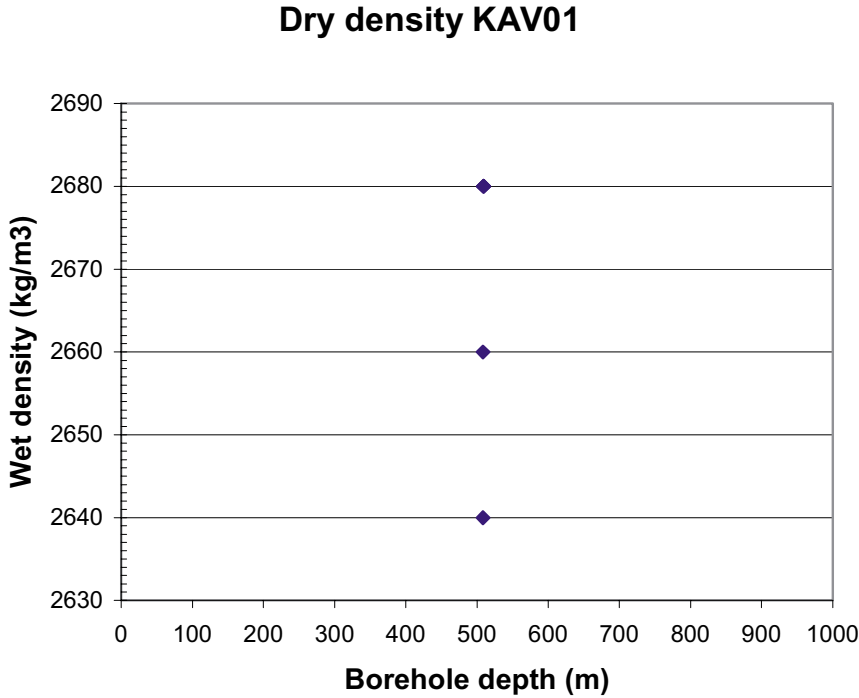


Figure 5-1. Density (dry) versus depth which the samples are taken in the borehole.

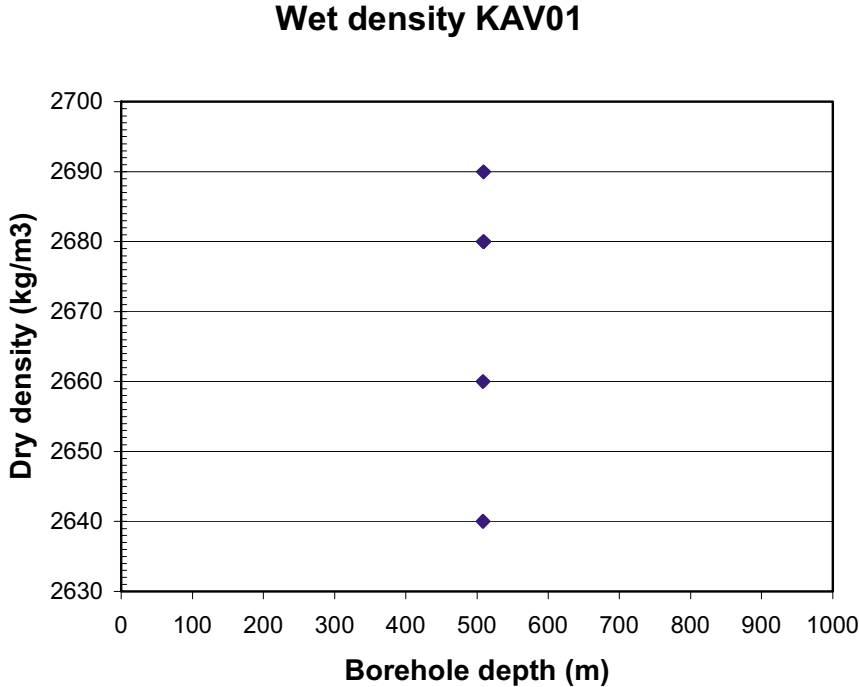
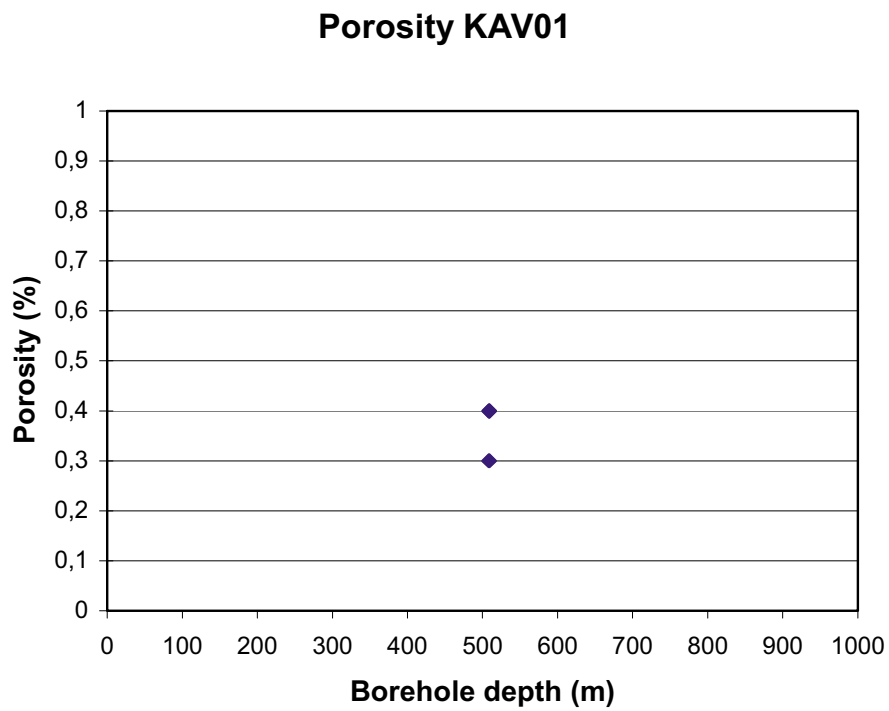


Figure 5-2. Density (wet) versus depth a which the samples are taken in the borehole.



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

### 5.3 Discussion

Non deviations have been done.

## References



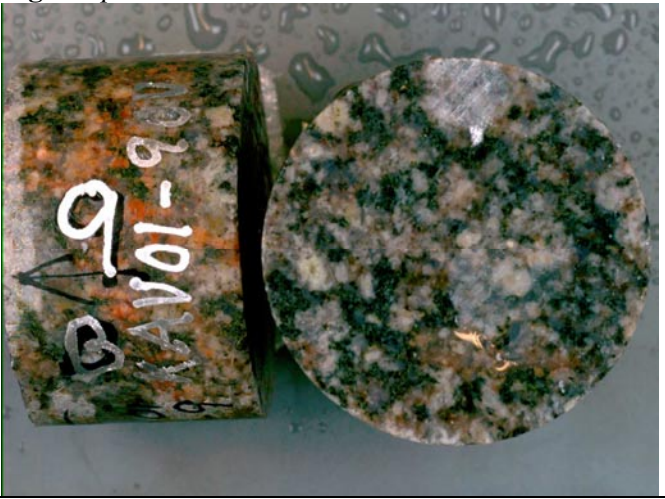
**EN 13755.** Natural stone test methods – Determination of water absorption at atmospheric pressure.

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

## Results and pictures

KAV01: Density and porosity

**Table 1:** Level 1 508-509 m, Specimen KAV01-090V-7 to KAV01-090V-11

<p>KAV01-90V-7 (508,25)</p> <p>The dry density for specimen KAV01-90V-7A was measured to be 2660 kg/m<sup>3</sup> and the porosity to 0,3 % and the dry density for specimen KAV01A-90V-7B was measured to be 2650 kg/m<sup>3</sup> and the porosity to 0,4 %.</p>	<p><b>Fig. 7.</b> Specimen KAV01-90V-7.</p> 
<p>KAV01-90V-8 (508,32)</p> <p>The dry density for specimen KAV01-90V-8A was measured to be 2660 kg/m<sup>3</sup> and the porosity to 0,3 % and the dry density for specimen KAV01-90V-8B was measured to be 2620 kg/m<sup>3</sup> and the porosity to 0,3 %.</p>	<p><b>Fig. 8.</b> Specimen KAV01-90V-8</p> 
<p>KAV01-90V-9 (509,09)</p> <p>The dry density for specimen KAV01-90V-9A was measured to be 2680 kg/m<sup>3</sup> and the porosity to 0,3 % and the dry density for specimen KAV01-90V-9B was measured to be 2670 kg/m<sup>3</sup> and the porosity to 0,3 %.</p>	<p><b>Fig. 9.</b> Specimen KAV01-90V-9.</p> 

KAV01-90V-10 (509,14)

The dry density for specimen KAV01-90V-10A was measured to be  $2670 \text{ kg/m}^3$  and the porosity to 0,4 % and the dry density for specimen KAV01-90V-10B was measured to be  $2680 \text{ kg/m}^3$  and the porosity to 0,4 %.

**Fig. 10.** Specimen KAV01-90V-10.



KAV01-90V-11 (509,20)

The dry density for specimen KAV01A-90V-11 was measured to be  $2680 \text{ kg/m}^3$  and the porosity to 0,4 % and the dry density for specimen KAV01-90V-11B was measured to be  $2680 \text{ kg/m}^3$  and the porosity to 0,3 %.

**Fig. 11.** Specimen KAV01-90V-11.



## Calculations of density and porosity

## Densitet och porositet, SKB

Uppdrags nr: P303920  
 Metod: EN 13755, ISRM (1973), avsnitt 3 samt SKB MD 160.002 version 1.0  
 Provad av: mhs  
 Datum: 2004-02-13

Provmärkning:	Vikt i vatten, Msub (g)	Yttor vikt, Msat (g)	Torr vikt, Ms (g)	Bulk volume, V (cm <sup>3</sup> )	Pore volume, Vv (cm <sup>3</sup> )	Porosity, n (%)	medel por	Dry density, pd (g/cm <sup>3</sup> )	medel dens	Wet density (g/cm <sup>3</sup> )	medel våt dens
1	KAV 01 90V-7A	58,34	93,31	93,19	35,02	0,12	0,4	2,66	2,66	2,66	2,66
2	KAV 01 90V-7B	58,12	93,15	93,02	35,08	0,13		2,65		2,66	
3	KAV 01 90V-8A	58,20	93,19	93,1	35,04	0,09	0,3	2,66	2,64	2,66	2,64
4	KAV 01 90V-8B	56,86	91,88	91,79	35,07	0,09		2,62		2,62	
5	KAV 01 90V-9A	59,31	94,50	94,39	35,24	0,11	0,3	2,68	2,68	2,68	2,68
6	KAV 01 90V-9B	59,06	94,22	94,11	35,21	0,11		2,67		2,68	
7	KAV 01 90V-10A	59,06	94,19	94,04	35,18	0,15	0,4	2,67	2,68	2,68	2,68
8	KAV 01 90V-10B	59,20	94,29	94,15	35,14	0,14		2,68		2,68	
9	KAV 01 90V-11A	59,18	94,18	94,05	35,05	0,13	0,4	2,68	2,68	2,69	2,69
10	KAV 01 90V-11B	59,28	94,36	94,24	35,13	0,12		2,68		2,69	
	Medel	58,661	93,727	93,608	35,119	0,119		2,665		2,669	
	std avvikelse	0,784	0,829	0,818	0,076	0,020		0,020		0,021	

Vattnets temperatur (°C): 18,9

Vattnets densitet (°C): 0,9985

Våg, inv.nr.:102291

Termometer, inv.nr.:100877