P-06-31

Oskarshamn site investigation Borehole KLX08

Thermal conductivity and thermal diffusivity determined using the TPS method

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October 2006

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Keywords: Thermal properties, Thermal conductivity, Thermal diffusivity, Heat capacity, Transient plane source method, AP PS 400-05-085.

Abstract

Thermal properties of ten specimens from borehole KLX08, Oskarshamn, Sweden, were measured at ambient temperature (20°C). The samples were collected randomly distributed at 20 m intervals from 630 m to 770 m and at the depth of 845 m. The rock types were Ävrö granite and diorit/gabbro. The determination of the thermal properties is based on a direct measurement method, the so called "Transient Plane Source Method" (TPS), Gustafsson, 1991 /2/.

Thermal conductivity and thermal diffusivity at 20°C were in the range of 2.21–3.13 W/(m, K) respectively 0.96–1.51 mm^2/s. The heat capacity, which was calculated from the thermal conductivity and diffusivity, ranged between 1.94 and 2.36 MJ/(m^3, K).

Sammanfattning

Termiska egenskaper hos 10 provkroppar från borrhål KLX08, Oskarshamn, bestämdes vid rumstemperatur (20 °C) med den s k TPS metoden (”Transient Plane Source”), Gustafsson 1991 /2/. Proverna från borrhålet hade tagits dels slumpmässigt med ca 20 m intervall från 630 m till 770 m och dels på 845 m djup där Ävrö granit och diorit-gabbro förekommer.

Den termiska konduktiviteten och den termiska diffusiviteten hos provkropparna vid 20 °C uppgick till 2,21–3,13 W/(m, K) respektive 0,96–1,51 mm^2/s. Från värdena på dessa parametrar kunde värmekapaciteten beräknas och befanns ligga i intervallet 1,94–2,36 MJ/(m^3, K).

Contents

1 Introduction

SKB is planning to build a final repository for nuclear waste in bedrock. A final repository for nuclear waste demands knowledge about thermal properties of the rock. Oskarshamn, Sweden, is one of the areas selected for site investigations. The activity presented in this report is part of the site investigation program at Oskarshamn /1/.

This report presents investigations of thermal properties of rock samples from borehole KLX08 at Oskarshamn. The thermal properties thermal conductivity and thermal diffusivity have been determined by using the Transient Plane Source Method (TPS), Gustafsson, 1991 /2/. The method determines thermal conductivity and diffusivity of a material. The volumetric heat capacity can be calculated if the density is known. The dry and wet densities, as well as porosity of the samples, were determined within the scope of a parallel activity /3/.

Rock samples were selected at Oskarshamn based on the preliminary core logging with the strategy to investigate the properties of the dominant rock types as well as of a number of minority rock types. The specimens to be tested were cut from the rock samples in the shape of circular discs. The rock samples arrived at SP in November 2005. The thermal properties were determined on water-saturated specimens. Testing was performed during February 2006.

The controlling documents for the activity are listed in Table 1-1. Activity Plan and Method Descriptions are SKB's (The Swedish Nuclear Fuel and waste Management Company) internal controlling documents as well as SP's (Swedish National Testing and Research Institute) Quality Plan (SP-QD 13.1).

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

Activity Plan	**Number**	**Version**
KLX08. Bergmekaniska och termiska laboratoriebestämningar	AP PS 400-05-085	1.0
Method Description	**Number**	**Version**
Determining thermal conductivity and thermal capacity by the TPS method	SKB MD 191.001	2.0
Quality Plan		
SP-QD 13.1		

Figure 1-1. *Location of all telescopic boreholes drilled up to November 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.*

2 Objective and scope

The purpose of this activity is to determine the thermal properties of rock specimens. The obtained thermal properties will be used as input data for mechanical and thermal analysis in a site descriptive model that will be established for the candidate area selected for site investigation at Oskarshamn.

3 Equipment

Technical devices for determination of the thermal properties in question were:

- Kapton sensor 5501, with a radius of 6.403 mm, and a power output of 0.7 W. The sensor 5501 fulfils the recommended relation between sensor radius and sample geometry of the samples in /4/.
- TPS-apparatus, Source meter Keithley 2400, Multi-meter Keithley 2000 and bridge, see Figure 3-1.
- PC + Microsoft Office and Hot Disk version 5.4.
- Stainless Sample holder.

Function control of TPS instrumentation was performed according to BRk-QB-M26-02 (SP quality document), see Appendix A.

The experimental set-up is shown in Figure 3-2.

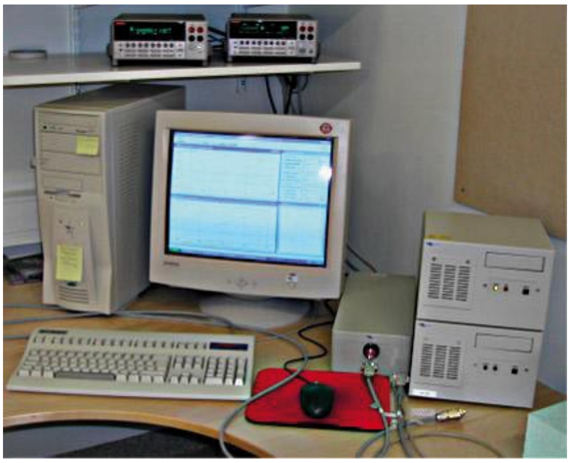

Figure 3-1. *TPS-apparatus with source meter, multi-meter, bridge, and computer.*

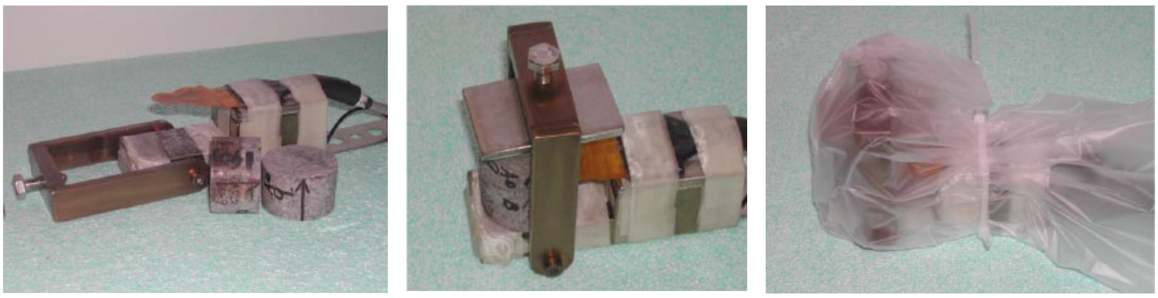

Figure 3-2. *Specimens prior to mounting (left), mounted in stainless sample holder (middle), and sample holder with mounted specimens wrapped in plastic (right).*

4 Execution

Determination of thermal properties conductivity and diffusivity was made in compliance with SKB's method description SKB MD 191.001 (SKB internal controlling document) and Hot Disc Instruction Manual /4/ at SP Fire Technology.

The density determinations, which were performed in a parallel activity at SP /3/, were carried out in accordance with SKB MD 160.002 (SKB internal controlling document) and ISRM /5/.

4.1 Description of the samples

10 pairs of cores (designated A and B) were sampled from borehole KLX08, Oskarshamn, Sweden. The cores were collected within the interval 630–845 m. The twenty specimens with a thickness of 25 mm each (see Figure 3-2) were cut from the rock samples at SP. The diameter of the specimens was about 50 mm. The identification marks, rock type and sampling levels of the specimens are presented in Table 4-1. Detailed geological description of the entire core of KLX08 is given in SKB's database SICADA (Boremap data).

Table 4-1. Identification marks, rock type and sampling level (borehole length) of the specimens from KLX08 for determination of thermal properties (rock-type classification according to Boremap). Each identification mark represents two specimens, designated A and B, respectively.

Identification	Rock type	Sampling level, (m borehole length) (Adj Sec low)
KLX08-90V-01	Ävrö granite (501044)	630.77
KLX08-90V-02	Diorite/gabbro (501033)	651.36
KLX08-90V-03	Ävrö granite (501044)	669.02
KLX08-90V-04	Diorite/gabbro (501033)	692.61
KLX08-90V-05	Diorite/gabbro (501033)	705.71
KLX08-90V-06	Ävrö granite (501044)	730.99
KLX08-90V-07	Diorite/gabbro (501033)	740.60
KLX08-90V-08	Ävrö granite (501044)	750.43
KLX08-90V-09	Diorite/gabbro (501033)	770.49
KLX08-90V-10	Diorite/gabbro (501033)	845.44

4.2 Test procedure

The present activity was performed parallel to another activity /3/, conducted by the department of Building Technology and Mechanics at SP, and by which the wet and dry density as well as the porosity of the specimens were determined.

The following logistic sequence was applied for the two activities:

1. Specimens were cut and polished by SP Building Technology and Mechanics.
2. Specimens were photographed by SP Building Technology and Mechanics.
3. Specimens were water saturated and wet density was determined by SP Building Technology and Mechanics /3/.
4. Specimens were sent from SP Building Technology and Mechanics to SP Fire Technology.
5. Thermal properties were determined by SP Fire Technology.
6. Specimens were sent from SP Fire Technology to SP Building Technology and Mechanics.
7. Dry density of the specimens was determined at SP Building Technology and Mechanics.

The principle of the TPS-method is to install a sensor consisting of a thin metal double spiral, embedded in an insulation material, between two rock samples. During the measurement the sensor works both as a heat emitter and a heat receptor. The input data and results of the direct measurement are registered and analysed by the same software and electronics that govern the measurement. The method gives information on the thermal conductivity and diffusivity of a material, and from the parameters the volumetric heat capacity can be determined, provided the density is known.

The specimens were water saturated and stored under this condition for 7 days. This yielded complete water saturation, whereupon the density and the thermal properties were determined. The specimens were photographed before testing.

The thermal properties of the water-saturated specimens were measured in ambient air (20°C). In order to remain water saturation and obtain desired temperature, the specimens and the sensor were kept in a plastic bag during the measurements, see Figure 3-2.

Each pair of specimens (A and B) was measured five times. The time lag between two repeated measurements was at least 20 minutes. The result of each measurement was evaluated separately. The average value of these five measurements was calculated.

Measured raw data were saved as text files and analysed data as Excel files. These files were stored on the hard disc of the measurement computer and sent to the SKB catalogue at the SP network. Further calculations of mean values and standard deviations were performed in the same catalogue.

Determinations of the thermal properties as well as density and porosity measurements were performed during February and March 2006.

The dry weight was measured after the specimens had been dried to constant mass according to ISMR /5/ at 105°C. The drying procedure took seven days.

4.3 Nonconformities

There were no deviations to the plan.

5 Results

The results of activity are stored in SKB´s database SICADA, where they are traceable by the Activity Plan number.

Mean values of measured data, five repeated measurements, are reported in 5.1 and 5.1.2 and in the SICADA database at SKB. Values of each separate measurement as described in Section 4.2 are reported in Appendix B. Furthermore, the total measuring time, the ratio between total measuring time and characteristic time, and the number of analysed points is presented in Appendix C. In a correct measurement the ratio between the total measuring time and the characteristic time should be between 0.4 and 1.

5.1 Test results of individual specimens

Specimens KLX08-90V-01A and B

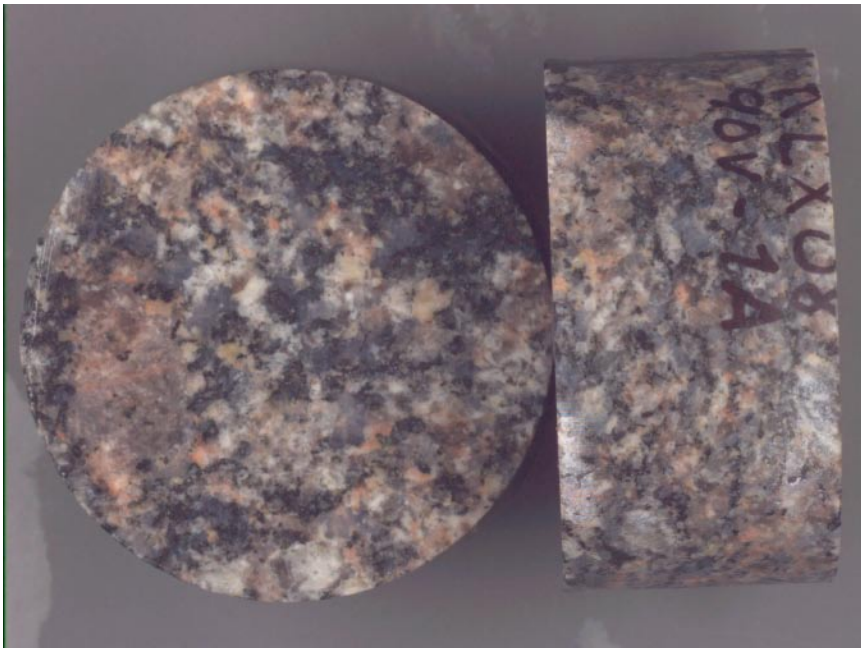

Figure 5-1. *Specimens KLX08-90V-01A and B.*

Table 5-1. Porosity, wet and dry density of specimens KLX08-90V-01A and B, average values.

Sample	Density, wet [kg/m³]	Density, dry [kg/m³]	Porosity [%]
KLX08-90V-01 Sec low: 630.77	2,680	2,680	0.8

Table 5-2. Thermal properties of specimens KLX08-90V-01A and B at ambient temperature, average values.

KLX08-90V-01 Sec low: 630.77	Conductivity [W/(m, K)]	Diffusivity [mm²/s]	Heat capacity [MJ/(m³, K)]
	20°C		
Mean value	3.13	1.32	2.36
Standard deviation	0.004	0.007	0.015

Specimens KLX08-90V-02A and B

Figure 5-2. *Specimens KLX08-90V-02A and B.*

Table 5-3. Porosity, wet and dry density of specimens KLX08-90V-02A and B, average values.

Sample	Density, wet [kg/m³]	Density, dry [kg/m³]	Porosity [%]
KLX08-90V-02 Sec low: 651.36	2,840	2,830	0.7

Table 5-4. Thermal properties of specimens KLX08-90V-02A and B at ambient temperature, average values.

KLX08-90V-02 Sec low: 651.36	Conductivity [W/(m, K)]	Diffusivity [mm²/s]	Heat capacity [MJ/(m³, K)]
	20°C		
Mean value	2.54	1.19	2.14
Standard deviation	0.011	0.013	0.032

Specimens KLX08-90V-03A and B

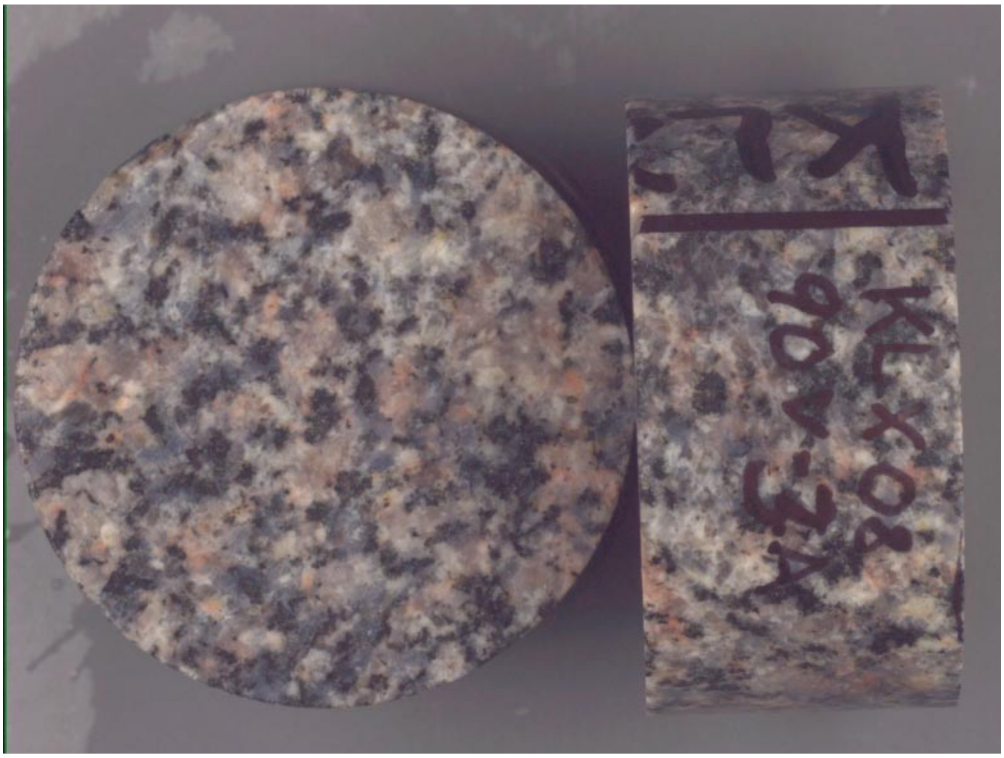

Figure 5-3. *Specimens KLX08-90V-03A and B.*

Table 5-5. Porosity, wet and dry density of specimens KLX08-90V-03A and B, average values.

Sample	Density, wet [kg/m³]	Density, dry [kg/m³]	Porosity [%]
KLX08-90V-03 Sec low: 669.02	2,680	2,670	0.7

Table 5-6. Thermal properties of specimens KLX08-90V-03A and B at ambient temperature, average values.

KLX08-90V-03 Sec low: 669.02	Conductivity [W/(m, K)]	Diffusivity [mm²/s]	Heat capacity [MJ/(m³, K)]
	20°C		
Mean value	3.07	1.51	2.03
Standard deviation	0.004	0.006	0.009

Specimens KLX08-90V-04A and B

Figure 5-4. *Specimens KLX08-90V-04A and B.*

Table 5-7. Porosity, wet and dry density of specimens KLX08-90V-04A and B, average values.

Sample	Density, wet [kg/m³]	Density, dry [kg/m³]	Porosity [%]
KLX08-90V-04 Sec low: 692.61	2,890	2,880	0.6

Table 5-8. Thermal properties of specimens KLX08-90V-04A and B at ambient temperature, average values.

KLX08-90V-04 Sec low: 692.61	Conductivity [W/(m, K)]	Diffusivity [mm²/s]	Heat capacity [MJ/(m³, K)]
	20°C		
Mean value	2.35	1.03	2.29
Standard deviation	0.001	0.001	0.003

Specimens KLX08-90V-05A and B

Figure 5-5. *Specimens KLX08-90V-05A and B.*

Table 5-9. Porosity, wet and dry density of specimens KLX08-90V-05A and B, average values.

Sample	Density, wet [kg/m³]	Density, dry [kg/m³]	Porosity [%]
KLX08-90V-05 Sec low: 705.71	2,890	2,880	0.6

Table 5-10. Thermal properties of specimens KLX08-90V-05A and B at ambient temperature, average values.

KLX08-90V-05 Sec low: 705.71	Conductivity [W/(m, K)]	Diffusivity [mm²/s]	Heat capacity [MJ/(m³, K)]
	20°C		
Mean value	2.55	1.19	2.14
Standard deviation	0.012	0.025	0.043

Specimens KLX08-90V-06A and B

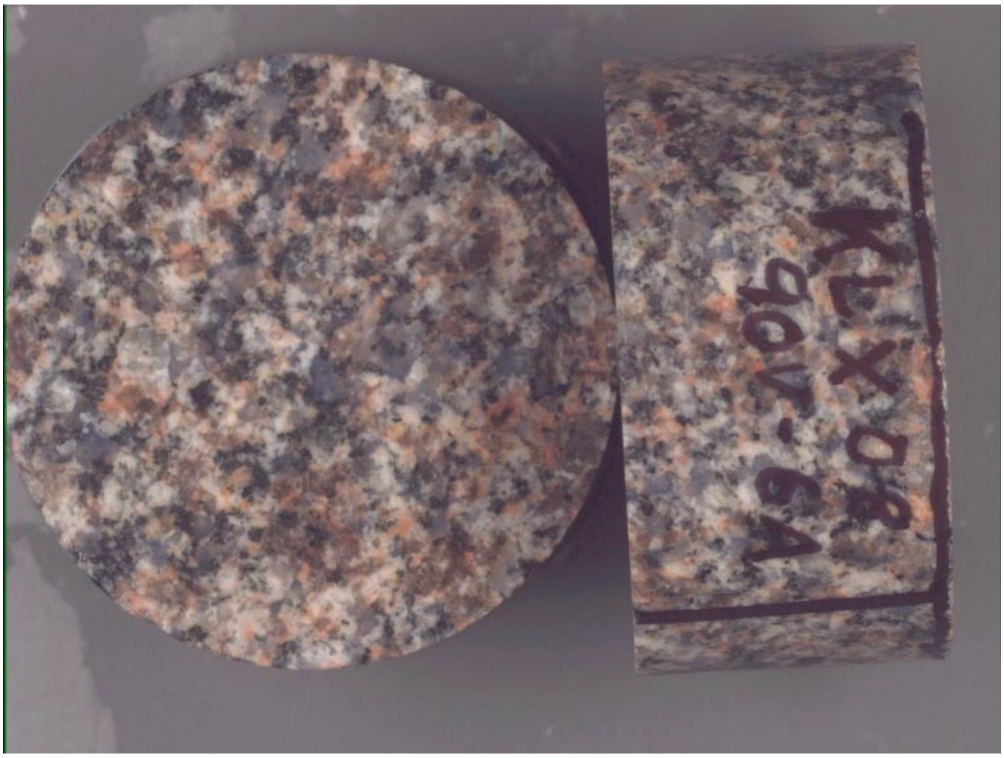

Figure 5-6. *Specimens KLX08-90V-06A and B.*

Table 5-11. Porosity, wet and dry density of specimens KLX08-90V-06A and B, average values.

Sample	Density, wet [kg/m³]	Density, dry [kg/m³]	Porosity [%]
KLX08-90V-06 Sec low: 730.99	2,670	2,670	0.8

Table 5-12. Thermal properties of specimens KLX08-90V-06A and B at ambient temperature, average values.

KLX08-90V-06 Sec low: 730.99	Conductivity [W/(m, K)]	Diffusivity [mm²/s]	Heat capacity [MJ/(m³, K)]
	20°C		
Mean value	3.12	1.46	2.14
Standard deviation	0.008	0.006	0.014

Specimens KLX08-90V-07A and B

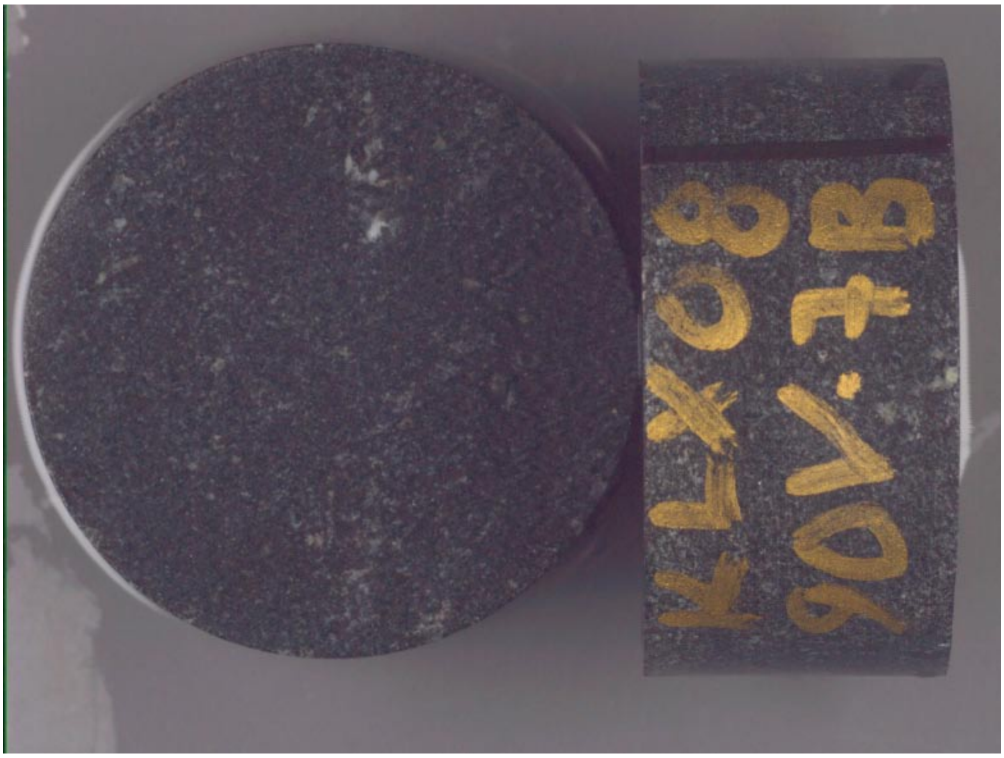

Figure 5-7. *Specimens KLX08-90V-07A and B.*

Table 5-13. Porosity, wet and dry density of specimens KLX08-90V-07A and B, average values.

Sample	Density, wet [kg/m³]	Density, dry [kg/m³]	Porosity [%]
KLX08-90V-07 Sec low: 740.60	2,960	2,960	0.6

Table 5-14. Thermal properties of specimens KLX08-90V-07A and B at ambient temperature, average values.

KLX08-90V-07 Sec low: 740.60	Conductivity [W/(m, K)]	Diffusivity [mm²/s]	Heat capacity [MJ/(m³, K)]
	20°C		
Mean value	2.21	0.96	2.31
Standard deviation	0.009	0.010	0.034

Specimens KLX08-90V-08A and B

Figure 5-8. *Specimens KLX08-90V-08A and B.*

Table 5-15. Porosity, wet and dry density of specimens KLX08-90V-08A and B, average values.

Sample	Density, wet [kg/m³]	Density, dry [kg/m³]	Porosity [%]
KLX08-90V-08 Sec low: 750.43	2,680	2,670	0.7

Table 5-16. Thermal properties of specimens KLX08-90V-08A and B at ambient temperature, average values.

KLX08-90V-08 Sec low: 750.43	Conductivity [W/(m, K)]	Diffusivity [mm²/s]	Heat capacity [MJ/(m³, K)]
	20°C		
Mean value	2.93	1.51	1.94
Standard deviation	0.005	0.007	0.010

Specimens KLX08-90V-09A and B

Figure 5-9. *Specimens KLX08-90V-09A and B.*

Table 5-17. Porosity, wet and dry density of specimens KLX08-90V-09A and B, average values.

Sample	Density, wet [kg/m³]	Density, dry [kg/m³]	Porosity [%]
KLX08-90V-09 Sec low: 770.49	2,900	2,890	0.7

Table 5-18. Thermal properties of specimens KLX08-90V-09A and B at ambient temperature, average values.

KLX08-90V-09 Sec low: 770.49	Conductivity [W/(m, K)]	Diffusivity [mm²/s]	Heat capacity [MJ/(m³, K)]
	20°C		
Mean value	2.53	1.11	2.27
Standard deviation	0.004	0.004	0.012

Specimens KLX08-90V-10A and B

Figure 5-10. *Specimens KLX08-90V-10A and B.*

Table 5-19. Porosity, wet and dry density of specimens KLX08-90V-10A and B, average values.

Sample	Density, wet [kg/m³]	Density, dry [kg/m³]	Porosity [%]
KLX08-90V-10 Sec low: 845.44	2,830	2,830	0.7

Table 5-20. Thermal properties of specimens KLX08-90V-10A and B at ambient temperature, average values.

KLX08-90V-10 Sec low: 845.44	Conductivity [W/(m, K)]	Diffusivity [mm²/s]	Heat capacity [MJ/(m³, K)]
	20°C		
Mean value	2.33	1.05	2.22
Standard deviation	0.002	0.002	0.005

5.2 Results for the entire test series

Table 5-21 displays the mean value of five repeated measurements of the thermal properties. Standard deviation is shown in Table 5-22. The results are in both tables grouped according to rock type. Thus the mean values are in this report given "per rock type" instead of as in previous reports "per level".

The thermal conductivity and thermal diffusivity of specimens representing different depths at 20°C were in the range 2.21–3.13 W/(m, K) respectively 0.96–1.51 mm^2/s. From these results the heat capacity was calculated and appeared to range between 1.94 and 2.36 MJ/(m^3, K). A graphical representation of the heat conductivity and heat capacity versus borehole length is given in Figure 5-11.

Table 5-21. Mean value of thermal properties of samples at 20°C.

Sample identification	Conductivity [W/(m, K)]	Diffusivity [mm^2/s]	Heat capacity [MJ/(m^3, K)]
Rock type Ävrö granit			
KLX08-90V-01	3.13	1.32	2.36
KLX08-90V-03	3.07	1.51	2.03
KLX08-90V-06	3.12	1.46	2.14
KLX08-90V-08	2.93	1.51	1.94
Mean value	3.06	1.45	2.12
Rock type diorit/gabbro			
KLX08-90V-02	2.54	1.19	2.14
KLX08-90V-04	2.35	1.03	2.29
KLX08-90V-05	2.55	1.19	2.14
KLX08-90V-07	2.21	0.96	2.31
KLX08-90V-09	2.53	1.11	2.27
KLX08-90V-10	2.33	1.05	2.22
Mean value	2.42	1.09	2.23

Table 5-22. Standard deviation of measured values at 20°C.

Sample identification	Conductivity [W/(m, K)]	Diffusivity [mm^2/s]	Heat capacity [MJ/(m^3, K)]
Rock type Ävrö granit			
KLX08-90V-01	0.004	0.007	0.015
KLX08-90V-03	0.004	0.006	0.009
KLX08-90V-06	0.008	0.006	0.014
KLX08-90V-08	0.005	0.007	0.010
Rock type diorit/gabbro			
KLX08-90V-02	0.011	0.013	0.032
KLX08-90V-04	0.001	0.001	0.003
KLX08-90V-05	0.012	0.025	0.043
KLX08-90V-07	0.009	0.010	0.034
KLX08-90V-09	0.004	0.004	0.012
KLX08-90V-10	0.002	0.002	0.005

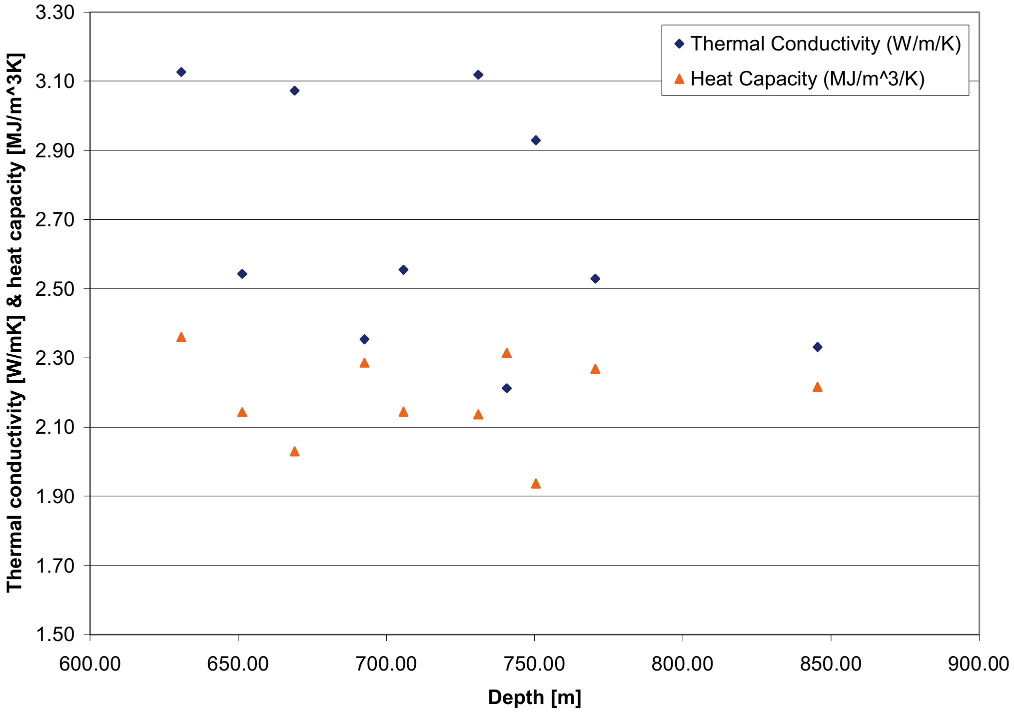

Figure 5-11. *Thermal conductivity and heat capacity versus borehole length at 20°C.*

6 References

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

/2/ **Gustafsson S E, 1991.** "Transient plane source techniques for thermal conductivity and thermal diffusivity measurements of solid materials". Rev. Sci. Instrum. 62 (3), March 1991, American Institute of Physics.

/3/ **Liedberg L, 2005.** Oskarshamn site investigation. Borehole KLX08. Determination of porosity by water saturation and density by buoyancy technique. SKB P-06-30, Svensk Kärnbränslehantering AB.

/4/ Instruction Manual Hot Disc Thermal Constants Analyser Windows 95 Version 5.0, 2001.

/5/ ISRM Commission on Testing Methods, ISRM, 1979.

Appendix A

Calibration protocol for Hot Disk Bridge System

Electronics:	Keithley 2400	Serial No. 0925167
	Keithley 2000	Serial No. 0921454
Hot Disk Bridge:		Serial No. 2003-0004
Computation Device:		Serial No. 2003-0003, ver 1.5
Computer:	Hot Disk computer	Serial No. 2003-0003
Test sample:	SIS2343. mild steel	Serial No. 3.52
Sensor for testing:	C5501	

Test measurement: 10 repeated measurements on the test sample at room temperature.

Conditions: Power 1 W. Measurement time 10s.

Results

Thermal Conductivity:	13.53 W/(m. K)	±0.05%
Thermal Diffusivity:	3.526 mm^2/s	±0.14%
Heat Capacity:	3.836 $MJ/(m^3. K)$	±0.17%

This instrument has proved to behave according to specifications described in BRk-QB-M26-02.

Borås 22/02 2006

Patrik Nilsson

Appendix B

Table B-1. Thermal properties of samples at 20°C.

Measurement number	Conductivity [W/(m, K)]	Diffusivity [mm²/s]	Heat capacity [MJ/(m³, K)]
KLX08-90V-01			
1	3.12	1.32	2.37
2	3.13	1.32	2.37
3	3.13	1.33	2.36
4	3.12	1.34	2.34
5	3.13	1.32	2.38
KLX08 90V-02			
1	2.53	1.20	2.10
2	2.55	1.18	2.16
3	2.55	1.17	2.18
4	2.54	1.19	2.12
5	2.55	1.18	2.16
KLX08 90V-03			
1	3.08	1.51	2.04
2	3.08	1.52	2.02
3	3.07	1.52	2.03
4	3.07	1.51	2.04
5	3.07	1.52	2.02
KLX08 90V-04			
1	2.35	1.03	2.29
2	2.35	1.03	2.29
3	2.35	1.03	2.29
4	2.35	1.03	2.29
5	2.35	1.03	2.28
KLX08 90V-05			
1	2.58	1.20	2.15
2	2.55	1.23	2.07
3	2.55	1.17	2.18
4	2.55	1.17	2.17
5	2.54	1.18	2.15
KLX08 90V-06			
1	3.12	1.45	2.15
2	3.13	1.46	2.15
3	3.12	1.46	2.14
4	3.11	1.47	2.12
5	3.11	1.46	2.12
KLX08 90V-07			
1	2.22	0.95	2.34
2	2.22	0.95	2.34
3	2.22	0.95	2.34
4	2.20	0.97	2.27
5	2.21	0.97	2.28

Measurement number	**Conductivity [W/(m, K)]**	**Diffusivity [mm^2/s]**	**Heat capacity [$MJ/(m^3, K)$]**
KLX08 90V-08			
1	2.93	1.52	1.92
2	2.94	1.51	1.95
3	2.93	1.51	1.94
4	2.93	1.51	1.93
5	2.93	1.51	1.94
KLX08 90V-09			
1	2.52	1.12	2.25
2	2.53	1.11	2.29
3	2.53	1.12	2.27
4	2.53	1.12	2.27
5	2.53	1.12	2.27
KLX08 90V-10			
1	2.33	1.05	2.22
2	2.33	1.05	2.22
3	2.33	1.05	2.22
4	2.33	1.05	2.21
5	2.33	1.05	2.22

Appendix C

Table C-1. Total time of measurement, ratio of total time and characteristic time, and number of analysed points at 20°C.

Measurement number	Total time(s)	Total/Char. Time	Points
KLX08-90V-01			
1	20	0.62	81–193
2	20	0.62	81–193
3	20	0.62	81–193
4	20	0.63	81–193
5	20	0.62	82–193
KLX08 90V-02			
1	20	0.58	84–200
2	20	0.57	84–200
3	20	0.57	84–200
4	20	0.58	84–200
5	20	0.57	84–199
KLX08 90V-03			
1	20	0.63	73–171
2	20	0.62	75–167
3	20	0.62	73–169
4	20	0.62	78–169
5	20	0.63	73–171
KLX08 90V-04			
1	20	0.50	33–200
2	20	0.50	33–200
3	20	0.50	33–200
4	20	0.50	34–200
5	20	0.50	33–200
KLX08 90V-05			
1	20	0.57	72–195
2	20	0.58	72–195
3	20	0.56	72–195
4	20	0.56	72–195
5	20	0.56	72–195
KLX08 90V-06			
1	20	0.70	35–200
2	20	0.71	35–200
3	20	0.71	35–200
4	20	0.71	35–200
5	20	0.71	35–200
KLX08 90V-07			
1	20	0.46	65–200
2	20	0.46	65–200
3	20	0.46	65–200
4	20	0.47	65–200
5	20	0.47	65–200

Measurement number	Total time(s)	Total/Char. Time	Points
KLX08 90V-08			
1	20	0.74	71–200
2	20	0.73	75–200
3	20	0.73	75–200
4	20	0.73	75–200
5	20	0.73	75–200
KLX08 90V-09			
1	20	0.54	37–200
2	20	0.54	37–200
3	20	0.54	37–200
4	20	0.54	37–200
5	20	0.54	37–200
KLX08 90V-10			
1	20	0.49	25–192
2	20	0.49	25–192
3	20	0.49	25–192
4	20	0.49	25–192
5	20	0.49	25–192