# P-05-169

# Oskarshamn site investigation

## Laxemar, surface samples

### Thermal properties: heat conductivity and heat capacity of surface samples determined using the TPS method

Carl Dinges, Hot Disk AB

June 2005

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*Keywords:* Thermal properties, Rock mechanics, Thermal conductivity, Thermal diffusivity, Heat capacity, Transient Plane Source method.

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.

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# Abstract

Thermal properties on ten surface specimens at south Laxemar, Oskarshamn, were measured at ambient temperature (23°C). The specimens were sampled on ten different locations. The investigated rock type is mapped as Quartzmonzodiorite.

The determination of the thermal properties are based on a direct measurement method, the so called Transient Plane Source Method (TPS), Gustafsson, 1991 /1/.

The thermal conductivity, and specific heat capacity ranged between 2.42–3.09 W/(m, K) and 2.00–2.24 MJ/$m^3$K respectively.

# Sammanfattning

Termiska egenskaper hos tio ytprovkroppar i södra Laxemarområdet, Oskarshamn, bestämdes vid rumstemperatur (23°C). Proverna har tagits från 10 olika platser inom området. Den karterade bergarten är kvartsmonzodiorit.

TPS metoden, "Transient Plane Source", användes för bestämning av de termiska egenskaperna, Gustafsson 1991 /1/.

Den termiska konduktiviteten och det specifika värmet hos provkropparna vid 23°C och vid olika djup var 2.42–3.09 W/(m, K) och 2.00–2.24 MJ/$m^3$K.

# Contents

# 1 Introduction

The objective of this investigation was to measure thermal properties of surface samples from south Laxemar, Oskarshamn, see Figure 1-1, at ambient temperature (23°C) by using the TPS-method /1/. The thermal properties were determined for water-saturated specimens. The samples, in form of cylinders, were drilling out from rock hand specimens.

The principle of the TPS method is to place a sensor between two rock samples. The sensor consists of a thin metal double spiral, embedded in an insulation material. 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 heat conductivity and diffusivity of a material and from this the volumetric heat capacity can be determined, if the density is known.

The test programme follows the activity plan AP PS 400-05-041 (SKB internal controlling document).

The samples were water saturated and stored in this condition for 7 days. This yields complete water saturation whereupon the density and the thermal properties were determined. The specimens were photographed after the testing was completed.

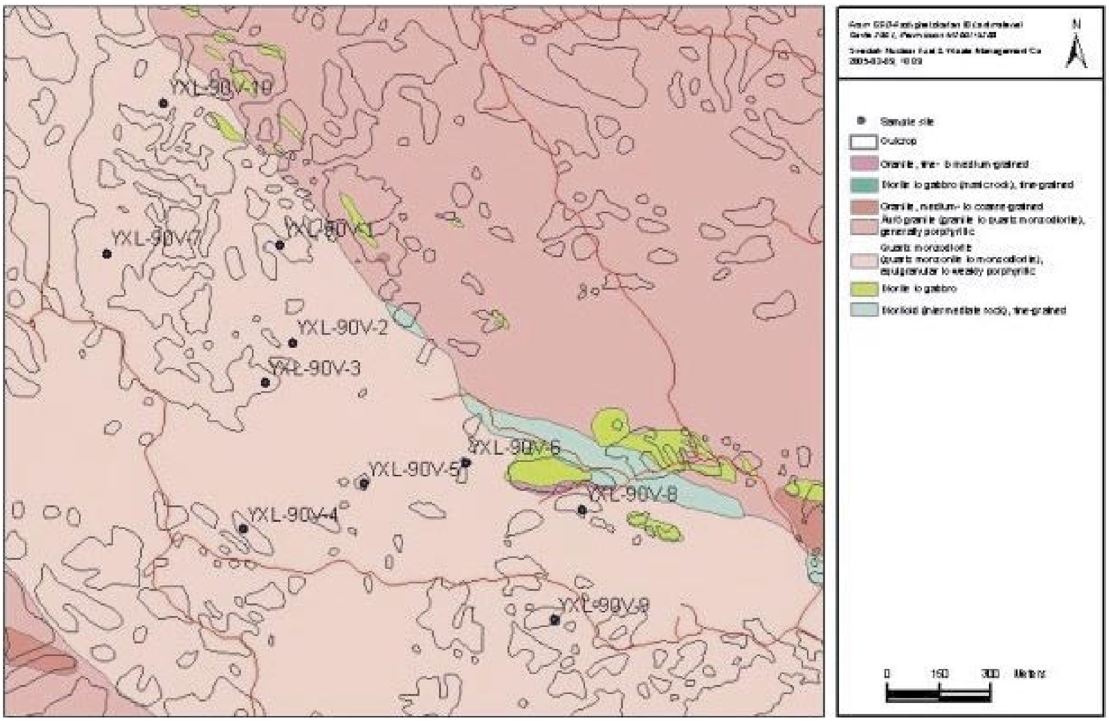


***Figure 1-1.** Location of the samples at south Laxemar, Oskarshamn site investigation.*

The rock hand specimens were first drilling out at SP. The rock cores arrived to Hot Disk AB in May 2005. The testing was performed during June 2005.

Determination of thermal properties was made in accordance to SKB's method description SKB MD 191.001 (SKB internal controlling document) at Hot Disk AB. Density was determined in accordance to SKB MD 160.002, (SKB internal controlling document) at Hot Disk AB.

# 2 Objective and scope

The purpose of the testing is to determine the thermal properties of rock specimens. The results shall be used for the site descriptive modelling of thermal properties, which will be established for the candidate area selected for site investigations at Oskarshamn.

The samples are from south Laxemar in Oskarshamn. The specimens were sampled on ten different locations in the area. The investigated rock type is mapped as Quartzmonzodiorite.

# 3 Equipment

Technical devices for determination of thermal properties used were:

- Kapton sensor 5501, radius of the sensor was 6.403 mm, and output of power was 0.7 W. The sensor 5501 fulfils the recommended relation between the radius of sensor and geometry of the samples in /2/.
- TPS-apparatus, Source meter Keithley 2400, Multi-meter Keithley 2000 and bridge, see Figure 3-1.
- PC + Microsoft Office and Hot Disk version 5.9.
- Stainless Sample holder

Specimen mounting is shown in Figure 3-2.

***Figure 3-1.*** *Hot disk Thermal Constants Analyser.*

***Figure 3-2.*** *Sample mounting.*

# 4 Execution

Determination of thermal properties was made in accordance to SKB's method description SKB MD 191.001 (SKB internal controlling document) and Hot Disk Instruction Manual /2/ at Hot Disk AB.

Density was determined in accordance to SKB MD 160.002 (SKB internal controlling document). Archimede's princip was used.

## 4.1 Description of the samples

Ten pairs of cores were sampled from the surface of ten different locations at south Laxemar. The 20 specimens had a rough thickness 20 mm and a diameter of 40 mm. The rock types, identification marks of the specimens are presented in Table 4-1. Detailed geological description of the rock is given in SKB's report P-04-221 /3/.

**Table 4-1. Rock types and identification marks (Rock-type classification according to P-04-221).**

| Id (P-04-221) | Sample id number | Rock type |
|---|---|---|
| PSM004964 | YLX-90V-1 | Quartzmonzodiorite |
| PSM004962 | YLX-90V-2 | Quartzmonzodiorite |
| PSM004959 | YLX-90V-3 | Quartzmonzodiorite |
| PSM005012 | YLX-90V-4 | Quartzmonzodiorite |
| PSM004007 | YLX-90V-5 | Quartzmonzodiorite |
| PSM004006 | YLX-90V-6 | Quartzmonzodiorite |
| PSM004484 | YLX-90V-7 | Quartzmonzodiorite |
| PSM003962 | YLX-90V-8 | Quartzmonzodiorite |
| PSM004054 | YLX-90V-9 | Quartzmonzodiorite |
| PSM004497 | YLX-90V-10 | Quartzmonzodiorite |

## 4.2 Test procedure

The following steps were performed:

1. Samples were drilling out and polished by SP, Building Technology and Mechanics, and then sent to Hot Disk AB for thermal characterization.
2. Samples were water saturated and wet density was determined by Hot Disk AB.
3. Thermal properties were determined.
4. Samples were photographed by Hot Disk AB.

Thermal properties of water-saturated specimens were measured in ambient air (23°C). In order to remain water saturation and obtain desired temperature, the samples and the sensor were kept in a plastic bag during the measurement, see Figure 3-2. A dead weight on top of the set-up ensured a stable measurement environment.

Each core pair was measured five times. The time lag between two repeated measurements was 20 minutes. The result of each measurement was evaluated separately. The average value of these five measurements was calculated.

A function control of the TPS instrumentation was performed, see Appendix A.

Measured raw data were saved as text files. Analysed data were saved as Excel files. These files were stored on the hard disc of the measurement computer. These stored files were sent to a server at Hot Disk AB. Further calculations of mean values and standard deviations were performed in the same catalogue.

Thermal properties and density measurements were performed during June 2005.

# 5 Results

## 5.1 Thermal properties

Mean values of measured data, five repeated measurements, are reported in 5.1.1 and 5.1.2 and in the SICADA database at SKB. Values of each separate measurement 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 0.3 and 1.

### 5.1.1 Test results, sample by sample

#### *Sample YLX-90V-01*


***Figure 5-1.*** *Specimens YLX-90V-01.*

**Table 5-1. Wet density of specimens YLX-90V-01.**

| Sample | Density (kg/m³) |
|---|---|
| YLX-90V-01 A | 2,790 |
| YLX-90V-01 B | 2,788 |

**Table 5-2. Thermal properties of sample YLX-90V-01 at ambient temperature.**

| YLX-90V-01 | Conductivity (W/(m, K)) | Diffusivity (mm²/s) | Heat capacity (MJ/(m³· K)) |
|---|---|---|---|
| 23°C | | | |
| Mean value | 2.42 | 1.11 | 2.18 |
| Standard deviation | 0.01 | 0.04 | 0.06 |

### *Sample YLX-90V-02*

***Figure 5-2.*** *Specimens YLX-90V-02.*

**Table 5-3. Wet density of specimens YLX-90V-02.**

| Sample | Density (kg/m$^3$) |
|---|---|
| YLX-90V-02 A | 2,783 |
| YLX-90V-02 B | 2,781 |

**Table 5-4. Thermal properties of sample YLX-90V-02 at ambient temperature.**

| YLX-90V-02 | Conductivity (W/(m, K)) | Diffusivity (mm$^2$/s) | Heat capacity (MJ/(m$^3$, K)) |
|---|---|---|---|
| 23°C | | | |
| Mean value | 2.56 | 1.19 | 2.15 |
| Standard deviation | 0.003 | 0.003 | 0.01 |

### *Sample YLX-90V-03*

***Figure 5-3.*** *Specimens YLX-90V-03.*

**Table 5-5. Wet density of specimens YLX-90V-03.**

| Sample | Density (kg/m³) |
|---|---|
| YLX-90V-03 A | 2,767 |
| YLX-90V-03 B | 2,766 |

**Table 5-6. Thermal properties of sample YLX-90V-03 at ambient temperature.**

| YLX-90V-03 | Conductivity (W/(m, K)) | Diffusivity (mm²/s) | Heat capacity (MJ/(m³, K)) |
|---|---|---|---|
| 23°C | | | |
| Mean value | 2.67 | 1.22 | 2.20 |
| Standard deviation | 0.01 | 0.003 | 0.01 |

### *Sample YLX-90V-04*

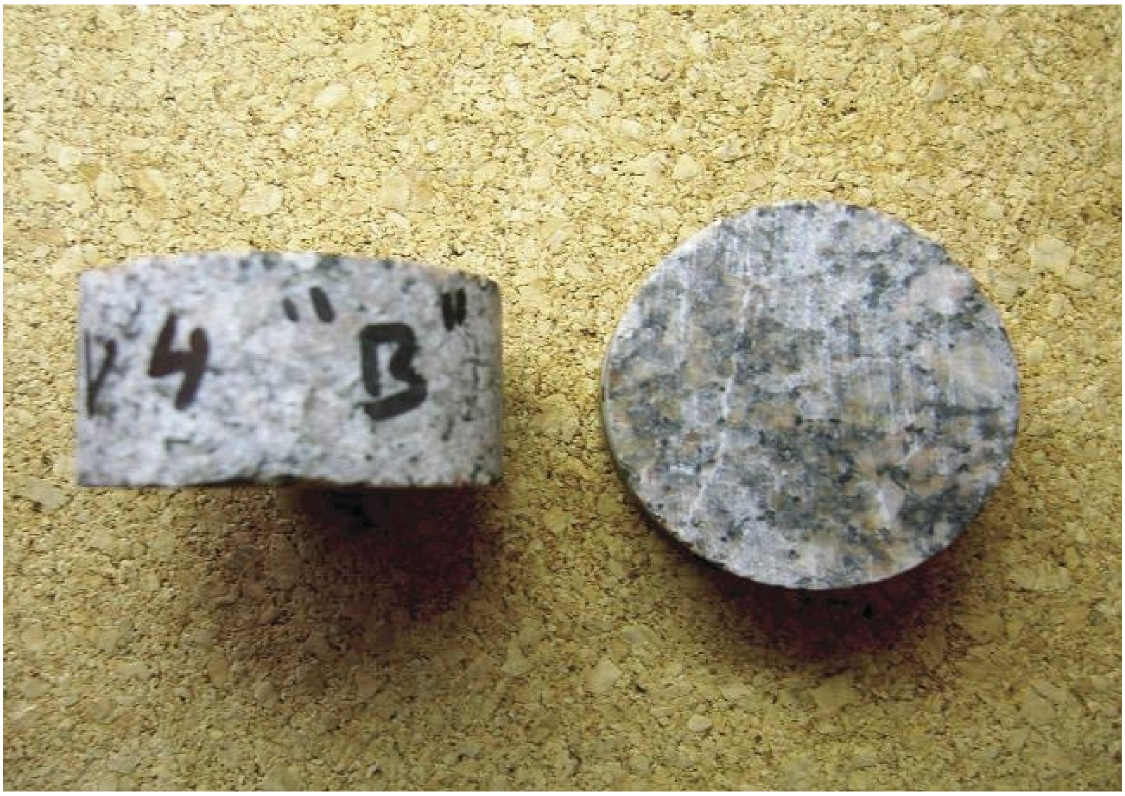

***Figure 5-4.*** *Specimens YLX-90V-04.*

**Table 5-7. Wet density of specimens YLX-90V-04.**

| Sample | Density (kg/m³) |
|---|---|
| YLX-90V-04 A | 2,712 |
| YLX-90V-04 B | 2,717 |

**Table 5-8. Thermal properties of sample YLX-90V-04 at ambient temperature.**

| YLX-90V-04 | Conductivity (W/(m, K)) | Diffusivity (mm²/s) | Heat capacity (MJ/(m³, K)) |
|---|---|---|---|
| 23°C | | | |
| Mean value | 3.09 | 1.54 | 2.00 |
| Standard deviation | 0.01 | 0.02 | 0.02 |

### *Sample YLX-90V-05*

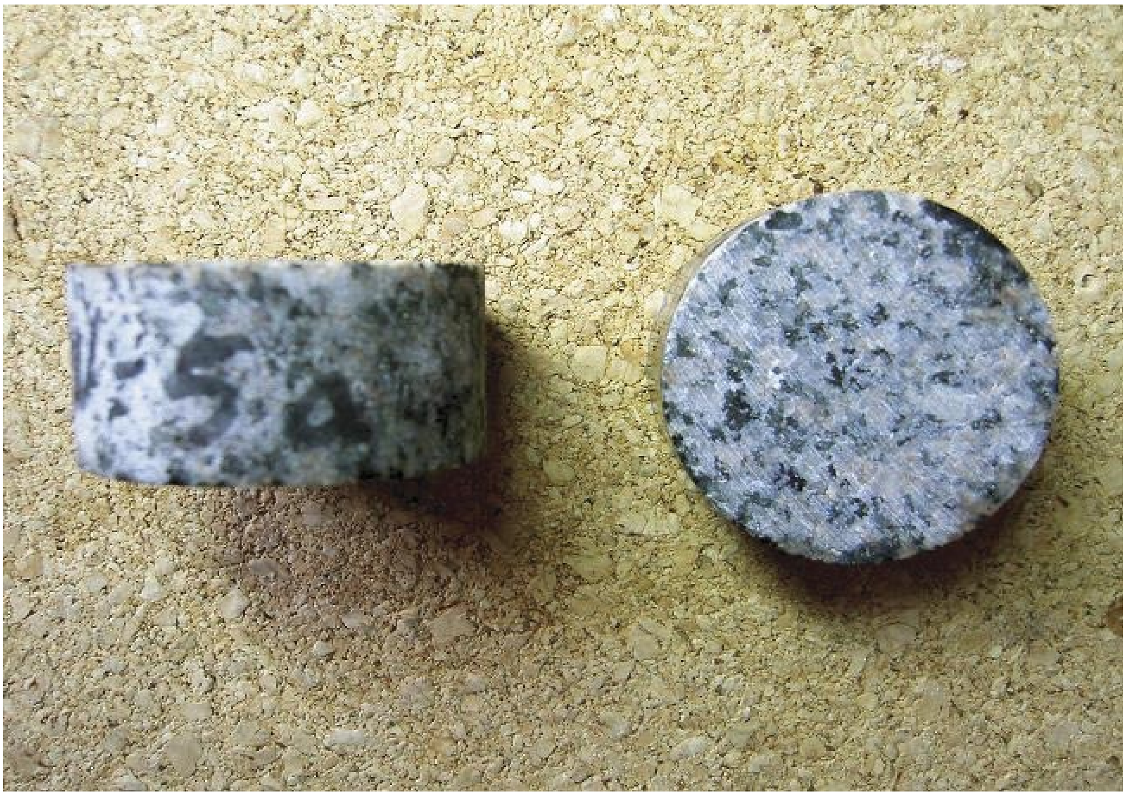

***Figure 5-5.*** *Specimens YLX-90V-05.*

**Table 5-9. Wet density of specimens YLX-90V-05.**

| Sample | Density (kg/m³) |
|---|---|
| YLX-90V-05 A | 2,770 |
| YLX-90V-05 B | 2,761 |

**Table 5-10. Thermal properties of sample YLX-90V-05 at ambient temperature.**

| YLX-90V-05 | Conductivity (W/(m, K)) | Diffusivity (mm²/s) | Heat capacity (MJ/(m³, K)) |
|---|---|---|---|
| 23°C | | | |
| Mean value | 2.66 | 1.20 | 2.22 |
| Standard deviation | 0.01 | 0.004 | 0.01 |

## *Sample YLX-90V-06*

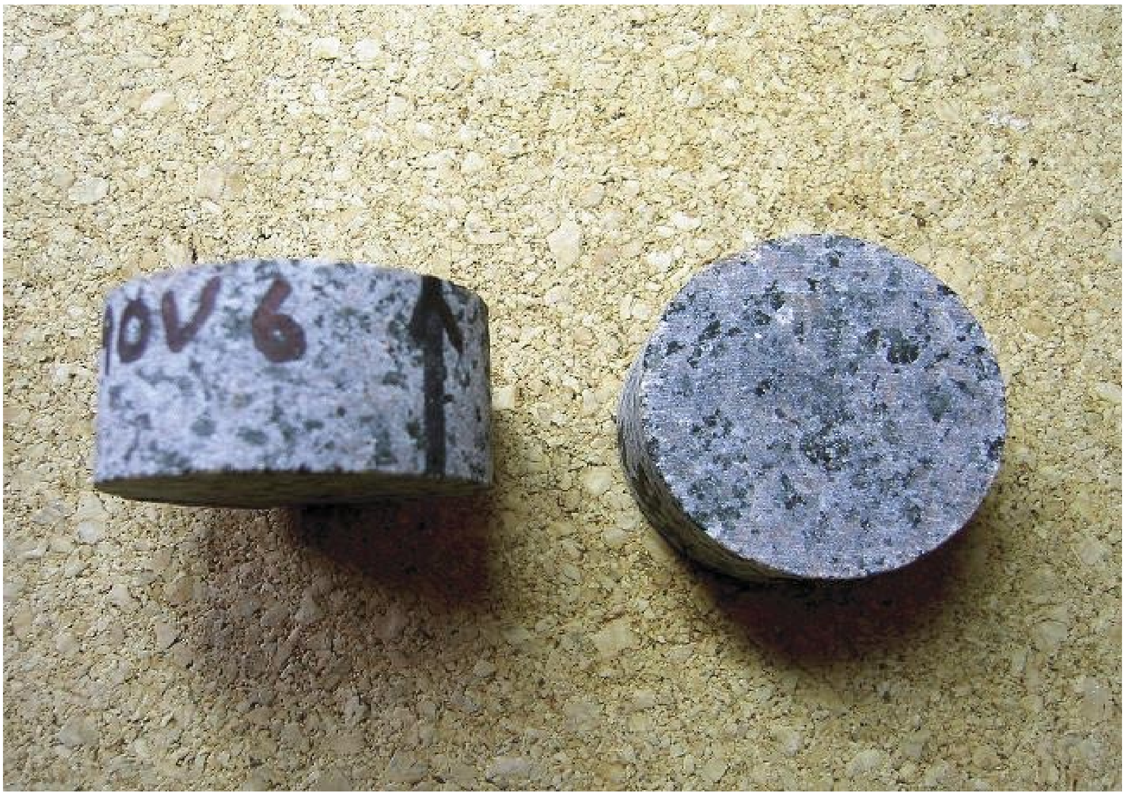

***Figure 5-6.*** *Specimens YLX-90V-06.*

**Table 5-11. Wet density of specimens YLX-90V-06.**

| Sample | Density (kg/m³) |
|---|---|
| YLX-90V-06 A | 2,767 |
| YLX-90V-06 B | 2,769 |

**Table 5-12. Thermal properties of sample YLX-90V-06 at ambient temperature.**

| YLX-90V-06 | Conductivity (W/(m, K)) | Diffusivity (mm²/s) | Heat capacity (MJ/(m³, K)) |
|---|---|---|---|
| 23°C | | | |
| Mean value | 2.62 | 1.18 | 2.21 |
| Standard deviation | 0.01 | 0.01 | 0.02 |

### *Sample YLX-90V-07*


***Figure 5-7.*** *Specimens YLX-90V-07.*

**Table 5-13. Wet density of specimens YLX-90V-07.**

| Sample | Density (kg/m³) |
|---|---|
| YLX-90V-07 A | 2,768 |
| YLX-90V-07 B | 2,756 |

**Table 5-14. Thermal properties of sample YLX-90V-07 at ambient temperature.**

| YLX-90V-07 | Conductivity (W/(m, K)) | Diffusivity (mm²/s) | Heat capacity (MJ/(m³, K)) |
|---|---|---|---|
| 23°C | | | |
| Mean value | 2.64 | 1.22 | 2.16 |
| Standard deviation | 0.01 | 0.004 | 0.01 |

### *Sample YLX-90V-08*


***Figure 5-8.*** *Specimens YLX-90V-08.*

**Table 5-15. Wet density of specimens YLX-90V-08.**

| Sample | Density (kg/m³) |
|---|---|
| YLX-90V-08 A | 2,809 |
| YLX-90V-08 B | 2,808 |

**Table 5-16. Thermal properties of sample YLX-90V-08 at ambient temperature.**

| YLX-90V-08 | Conductivity (W/(m, K)) | Diffusivity (mm²/s) | Heat capacity (MJ/(m³, K)) |
|---|---|---|---|
| 23°C | | | |
| Mean value | 2.43 | 1.14 | 2.14 |
| Standard deviation | 0.001 | 0.01 | 0.01 |

### *Sample YLX-90V-09*


***Figure 5-9.*** *Specimens YLX-90V-09.*

**Table 5-17. Wet density of specimens YLX-90V-09.**

| Sample | Density (kg/m³) |
|---|---|
| YLX-90V-09 A | 2,763 |
| YLX-90V-09 B | 2,757 |

**Table 5-18. Thermal properties of sample YLX-90V-09 at ambient temperature.**

| YLX-90V-09 | Conductivity (W/(m, K)) | Diffusivity (mm²/s) | Heat capacity (MJ/(m³, K)) |
|---|---|---|---|
| 23°C | | | |
| Mean value | 2.77 | 1.23 | 2.24 |
| Standard deviation | 0.01 | 0.004 | 0.01 |

### *Sample YLX-90V-10*

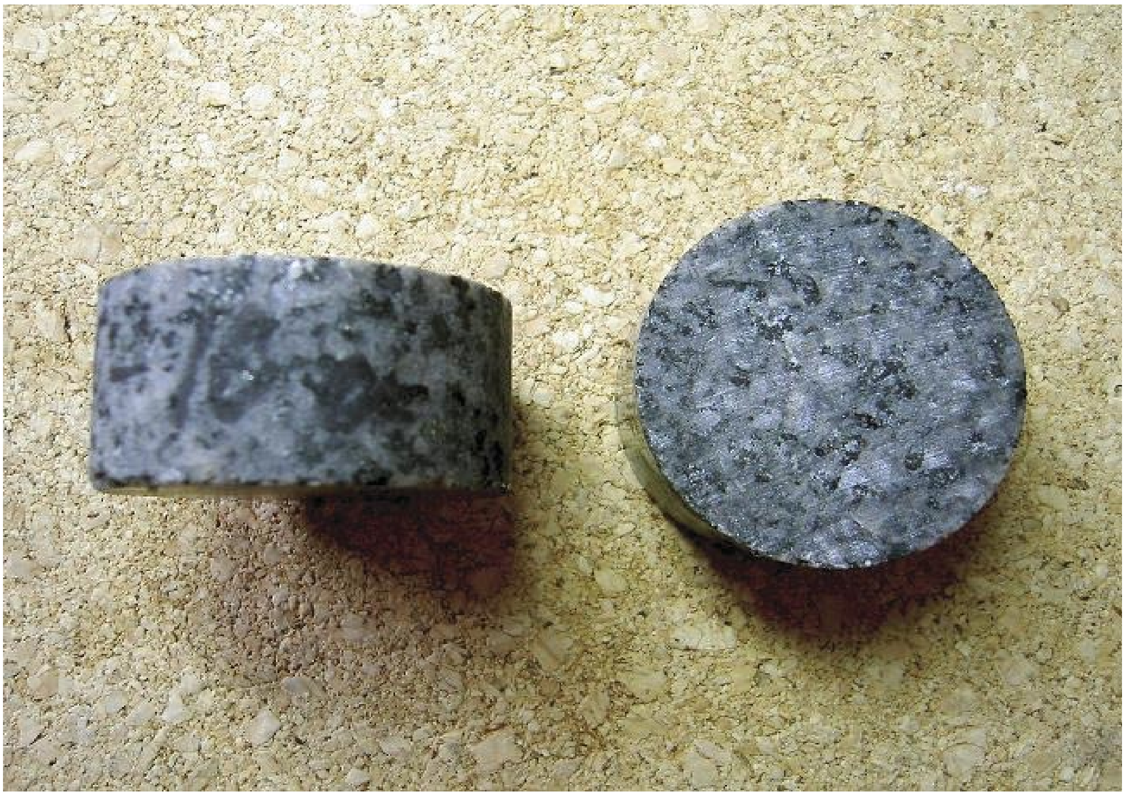

***Figure 5-10.*** *Specimens YLX-90V-10.*

**Table 5-19. Wet density of specimens YLX-90V-10.**

| Sample | Density (kg/m³) |
|---|---|
| YLX-90V-10 A | 2,788 |
| YLX-90V-10 B | 2,794 |

**Table 5-20. Thermal properties of sample YLX-90V-10 at ambient temperature.**

| YLX-90V-10 | Conductivity (W/(m, K)) | Diffusivity (mm²/s) | Heat capacity (MJ/(m³, K)) |
|---|---|---|---|
| 23°C | | | |
| Mean value | 2.43 | 1.09 | 2.23 |
| Standard deviation | 0.02 | 0.01 | 0.01 |

### 5.1.2 Results for the entire test series

Table 5-13 shows the mean value of five repeated measurements of the thermal properties. Standard deviation is shown in Table 5-14.

Thermal conductivity and thermal diffusivity of specimens at different positions at 23°C were in the range of 2.42–3.09 W/(m, K) and 1.09–1.54 mm²/s respectively.

Variation of the thermal conductivity in relation to sampling position is shown in Figure 5-11.

A rather large thermal conductivity variation between the different samples could be observed. The thermal conductivity, and specific heat capacity ranged between 2.42–3.09 W/(m, K) and 2.00–2.24 MJ/m³K respectively. This difference in thermal conductivity value can possibly be explained by the structure of the individual samples.

**Table 5-13. Mean value of thermal properties of samples at 23°C.**

| Sample identification | Conductivity (W/(m, K)) | Diffusivity (mm²/s) | Heat capacity (MJ/(m³, K)) |
|---|---|---|---|
| YLX-90V-01 | 2.42 | 1.11 | 2.18 |
| YLX-90V-02 | 2.56 | 1.19 | 2.15 |
| YLX-90V-03 | 2.67 | 1.22 | 2.20 |
| YLX-90V-04 | 3.09 | 1.54 | 2.00 |
| YLX-90V-05 | 2.66 | 1.20 | 2.22 |
| YLX-90V-06 | 2.62 | 1.18 | 2.21 |
| YLX-90V-07 | 2.64 | 1.22 | 2.16 |
| YLX-90V-08 | 2.43 | 1.14 | 2.14 |
| YLX-90V-09 | 2.77 | 1.23 | 2.24 |
| YLX-90V-10 | 2.43 | 1.09 | 2.23 |

**Table 5-14. Standard deviation of measured values at 23°C.**

| Sample identification | Conductivity (W/(m, K)) | Diffusivity (mm²/s) | Heat capacity (MJ/(m³, K)) |
|---|---|---|---|
| YLX-90V-01 | 0.01 | 0.04 | 0.06 |
| YLX-90V-02 | 0.003 | 0.003 | 0.01 |
| YLX-90V-03 | 0.01 | 0.003 | 0.01 |
| YLX-90V-04 | 0.01 | 0.02 | 0.02 |
| YLX-90V-05 | 0.01 | 0.004 | 0.01 |
| YLX-90V-06 | 0.01 | 0.01 | 0.02 |
| YLX-90V-07 | 0.01 | 0.004 | 0.01 |
| YLX-90V-08 | 0.001 | 0.01 | 0.01 |
| YLX-90V-09 | 0.01 | 0.004 | 0.01 |
| YLX-90V-10 | 0.02 | 0.01 | 0.01 |

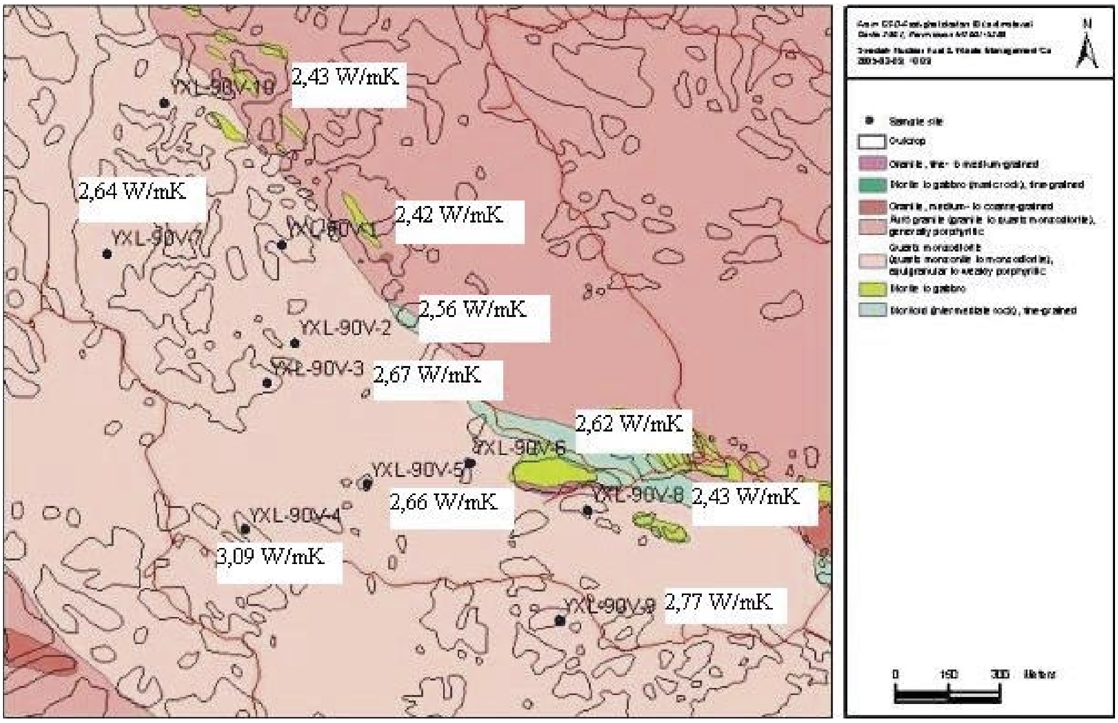


*__Figure 5-11.__ Thermal conductivity (in W/mK) at different locations at 23°C.*

## 5.2 Discussion

There were no deviations to the plans.

Since all measurements were successfully carried out, no extra measurements was needed. A trend that the thermal conductivity values decreased measurement by measurement can possibly be observed. This decrease in thermal conductivity for some of the samples is of the order of 0.5% from measurement 1 to measurement 5 and can be explained by surface drying of the sample.

# 6 References

/1/ **Gustafsson, S E, 1991.** Transient plane source techniques for thermal conductivity and thermal diffusivity measurements of solid material. Rev. Sci. Instrum. 62 (3), March 1991, American Institute of Physics.

/2/ Instruction Manual Hot Disc Thermal Constants Analyser Windows 95 Version 5.0, 2001.

/3/ **Nilsson K P, Bergman T, Eliasson T, 2004.** Bedrock mapping 2004 – Laxemar subarea and regional model area. Outcrop data and description of rock types. Oskarshamn site investigation. SKB P-04-221, Svensk Kärnbränslehantering AB.

# Appendix A

| | |
|---|---|
| **Instrument:** | Hot Disk AB test instrument |
| **Tested sample:** | SIS 2343 mildsteel |
| **Keithley 2000:** | 0735620 |
| **Keithley 2400:** | 0765732 |
| **Bridge unit:** | 2004-0024 |

**Test conditions**

| | |
|---|---|
| Power: | 1 W |
| Sensor: | C5501 |
| Measurement time: | 10 s |
| Number of measurements: | 5 |

**Test results**

| | |
|---|---|
| Thermal conductivity (W/mK): | 13,532 +/–0.008 |
| Thermal diffusivity ($mm^2/s$): | 3.487 +/–0.008 |
| Specific heat capacity ($MJ/m^3K$): | 3.88 +/–0.01 |

This instrument has proven to behave according to specifications.

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# Appendix B

**Table B-1. Thermal properties of samples at 23°C.**

| Temperature (°C) | Th conductivity (W/mK) | Th diffusivity ($mm^2/s$) | Spec heat ($MJ/m^3K$) |
|---|---|---|---|
| **YLX-90V-01** | | | |
| 23 | 2.40 | 1.05 | 2.30 |
| 23 | 2.43 | 1.12 | 2.17 |
| 23 | 2.42 | 1.12 | 2.16 |
| 23 | 2.42 | 1.13 | 2.14 |
| 23 | 2.42 | 1.12 | 2.15 |
| **YLX-90V-02** | | | |
| 23 | 2.56 | 1.19 | 2.16 |
| 23 | 2.56 | 1.19 | 2.15 |
| 23 | 2.56 | 1.19 | 2.14 |
| 23 | 2.56 | 1.20 | 2.14 |
| 23 | 2.56 | 1.19 | 2.15 |
| **YLX-90V-03** | | | |
| 23 | 2.68 | 1.21 | 2.21 |
| 23 | 2.68 | 1.22 | 2.20 |
| 23 | 2.67 | 1.22 | 2.19 |
| 23 | 2.67 | 1.22 | 2.20 |
| 23 | 2.66 | 1.22 | 2.19 |
| **YLX-90V-04** | | | |
| 23 | 3.11 | 1.56 | 2.00 |
| 23 | 3.10 | 1.56 | 1.99 |
| 23 | 3.09 | 1.55 | 2.00 |
| 23 | 3.10 | 1.52 | 2.04 |
| 23 | 3.07 | 1.54 | 2.00 |
| **YLX-90V-05** | | | |
| 23 | 2.66 | 1.19 | 2.23 |
| 23 | 2.67 | 1.19 | 2.23 |
| 23 | 2.66 | 1.19 | 2.23 |
| 23 | 2.65 | 1.20 | 2.21 |
| 23 | 2.65 | 1.20 | 2.21 |
| **YLX-90V-06** | | | |
| 23 | 2.63 | 1.18 | 2.23 |
| 23 | 2.62 | 1.18 | 2.22 |
| 23 | 2.62 | 1.19 | 2.20 |
| 23 | 2.61 | 1.19 | 2.19 |
| 23 | 2.61 | 1.18 | 2.22 |

| | | | |
|---|---|---|---|
| **YLX-90V-07** | | | |
| 23 | 2.65 | 1.22 | 2.17 |
| 23 | 2.64 | 1.22 | 2.16 |
| 23 | 2.64 | 1.22 | 2.16 |
| 23 | 2.63 | 1.23 | 2.14 |
| 23 | 2.63 | 1.22 | 2.16 |
| **YLX-90V-08** | | | |
| 23 | 2.43 | 1.13 | 2.15 |
| 23 | 2.43 | 1.14 | 2.14 |
| 23 | 2.43 | 1.14 | 2.13 |
| 23 | 2.43 | 1.14 | 2.13 |
| 23 | 2.43 | 1.14 | 2.14 |
| **YLX-90V-09** | | | |
| 23 | 2.78 | 1.23 | 2.25 |
| 23 | 2.77 | 1.24 | 2.24 |
| 23 | 2.77 | 1.23 | 2.25 |
| 23 | 2.77 | 1.23 | 2.25 |
| 23 | 2.76 | 1.24 | 2.23 |
| **YLX-90V-10** | | | |
| 23 | 2.46 | 1.11 | 2.22 |
| 23 | 2.44 | 1.08 | 2.26 |
| 23 | 2.43 | 1.09 | 2.24 |
| 23 | 2.42 | 1.09 | 2.23 |
| 23 | 2.42 | 1.09 | 2.22 |

# Appendix C

**Table C-1. Total time of measurement, ratio of total time and characteristic time, and number of analysed points at 23°C.**

| Measurement number | Total time (s) | Total/Char time | Points |
|---|---|---|---|
| **YLX-90V-01** | | | |
| 1 | 20 | 0.51 | 58–200 |
| 2 | 20 | 0.54 | 58–200 |
| 3 | 20 | 0.55 | 58–200 |
| 4 | 20 | 0.55 | 58–200 |
| 5 | 20 | 0.55 | 58–200 |
| **YLX-90V-02** | | | |
| 1 | 20 | 0.58 | 24–200 |
| 2 | 20 | 0.58 | 25–200 |
| 3 | 20 | 0.58 | 25–200 |
| 4 | 20 | 0.58 | 25–200 |
| 5 | 20 | 0.58 | 25–200 |
| **YLX-90V-03** | | | |
| 1 | 20 | 0.59 | 30–200 |
| 2 | 20 | 0.59 | 30–200 |
| 3 | 20 | 0.59 | 30–200 |
| 4 | 20 | 0.59 | 30–200 |
| 5 | 20 | 0.59 | 30–200 |
| **YLX-90V-04** | | | |
| 1 | 20 | 0.76 | 42–200 |
| 2 | 20 | 0.76 | 42–200 |
| 3 | 20 | 0.75 | 42–200 |
| 4 | 20 | 0.74 | 40–200 |
| 5 | 20 | 0.75 | 39–200 |
| **YLX-90V-05** | | | |
| 1 | 20 | 0.58 | 29–200 |
| 2 | 20 | 0.58 | 30–200 |
| 3 | 20 | 0.58 | 30–200 |
| 4 | 20 | 0.58 | 34–200 |
| 5 | 20 | 0.58 | 33–200 |
| **YLX-90V-06** | | | |
| 1 | 20 | 0.57 | 19–200 |
| 2 | 20 | 0.57 | 19–200 |
| 3 | 20 | 0.58 | 19–200 |
| 4 | 20 | 0.58 | 19–200 |
| 5 | 20 | 0.57 | 20–200 |

| | | | |
|---|---|---|---|
| **YLX-90V-07** | | | |
| 1 | 20 | 0.59 | 59–200 |
| 2 | 20 | 0.59 | 57–200 |
| 3 | 20 | 0.59 | 57–200 |
| 4 | 20 | 0.60 | 57–200 |
| 5 | 20 | 0.59 | 56–200 |
| **YLX-90V-08** | | | |
| 1 | 20 | 0.55 | 12–200 |
| 2 | 20 | 0.55 | 12–200 |
| 3 | 20 | 0.55 | 12–200 |
| 4 | 20 | 0.55 | 13–200 |
| 5 | 20 | 0.55 | 12–200 |
| **YLX-90V-09** | | | |
| 1 | 20 | 0.60 | 66–200 |
| 2 | 20 | 0.60 | 66–200 |
| 3 | 20 | 0.60 | 66–200 |
| 4 | 20 | 0.60 | 66–200 |
| 5 | 20 | 0.60 | 66–200 |
| **YLX-90V-10** | | | |
| 1 | 20 | 0.54 | 81–200 |
| 2 | 20 | 0.53 | 80–200 |
| 3 | 20 | 0.53 | 80–200 |
| 4 | 20 | 0.53 | 80–200 |
| 5 | 20 | 0.53 | 80–200 |