

Oskarshamn site investigation

Drill hole KLX03A

Determination of porosity by water saturation and density by buoyancy technique

M Savukoski

SP Swedish National Testing and Research Institute

March 2005

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 KLX03A

Determination of porosity by water saturation and density by buoyancy technique

M Savukoski

SP Swedish National Testing and Research Institute

March 2005

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

Abstract

The density and porosity has been determined on 15 specimens (each divided in two pieces) from drill hole KLX03A. The specimens were sampled on three levels in the drill hole: 290–320 m, 510–520 m and 690–710 m. The investigated rock types are mapped as Ävrö granite for level 1 and 2 (290–320 m and 510–520 m), for level 3 (690–710 m) the rock type was mapped as Quartz monzodiorite. The results for dry density varied between 2,760 and 2,810 kg/m³, for wet density the results varied between 2,760 and 2,820 kg/m³ and the results for porosity varied between 0.2 and 0.4%.

Sammanfattning

Densiteten och porositeten har bestämts på 15 provkroppar (varje provkropp delad i två delar) från borrhål KLX03A. Proverna togs från tre nivåer i borrhålet: 290–320 m, 510–520 m och 690–710 m. De undersökta bergartstyperna är karterade som Ävrögranit för nivå 1 och 2 (290–320 m och 510–520 m), och nivå 3 (690–710 m) är karterad som kvartsmonzodiorit. Resultaten för den torra densiteten varierade mellan 2 760 och 2 810 kg/m³, för den våta densiteten varierade resultaten mellan 2 760 och 2 820 kg/m³ och resultaten för porositeten varierade mellan 0,2 och 0,4 %.

Contents

| | | |
|----------|--|----|
| 1 | Introduction | 7 |
| 2 | Objective and scope | 9 |
| 3 | Equipment | 11 |
| 4 | Execution | 13 |
| 4.1 | Description of the samples | 13 |
| 4.2 | Testing | 14 |
| 4.3 | Nonconformities | 14 |
| 5 | Results | 15 |
| 5.1 | Summary of results | 15 |
| 5.2 | Discussion | 17 |
| | References | 19 |
| | Appendix 1 KLX03A: Density and porosity | 21 |

1 Introduction

The purpose is to determine the porosity and the water saturated and dry density of the samples.

The cores are sampled from borehole KLX03A in the Laxemar area. Thomas Janson and Björn Ljunggren, Tyréns AB, sampled them 23 November 2004. Specimens were taken from three levels in the rock core: level 1 between 290 and 320 m, level 2 between 510 and 520 m, level 3 between 690 and 710 m. The samples were selected based on the preliminary core logging, and with the strategy to primarily investigate the properties of the dominant rock properties. The rock cores were transported from Laxemar and arrived to SP December 2004. The testing commenced in January 2005 and ended in March 2005.

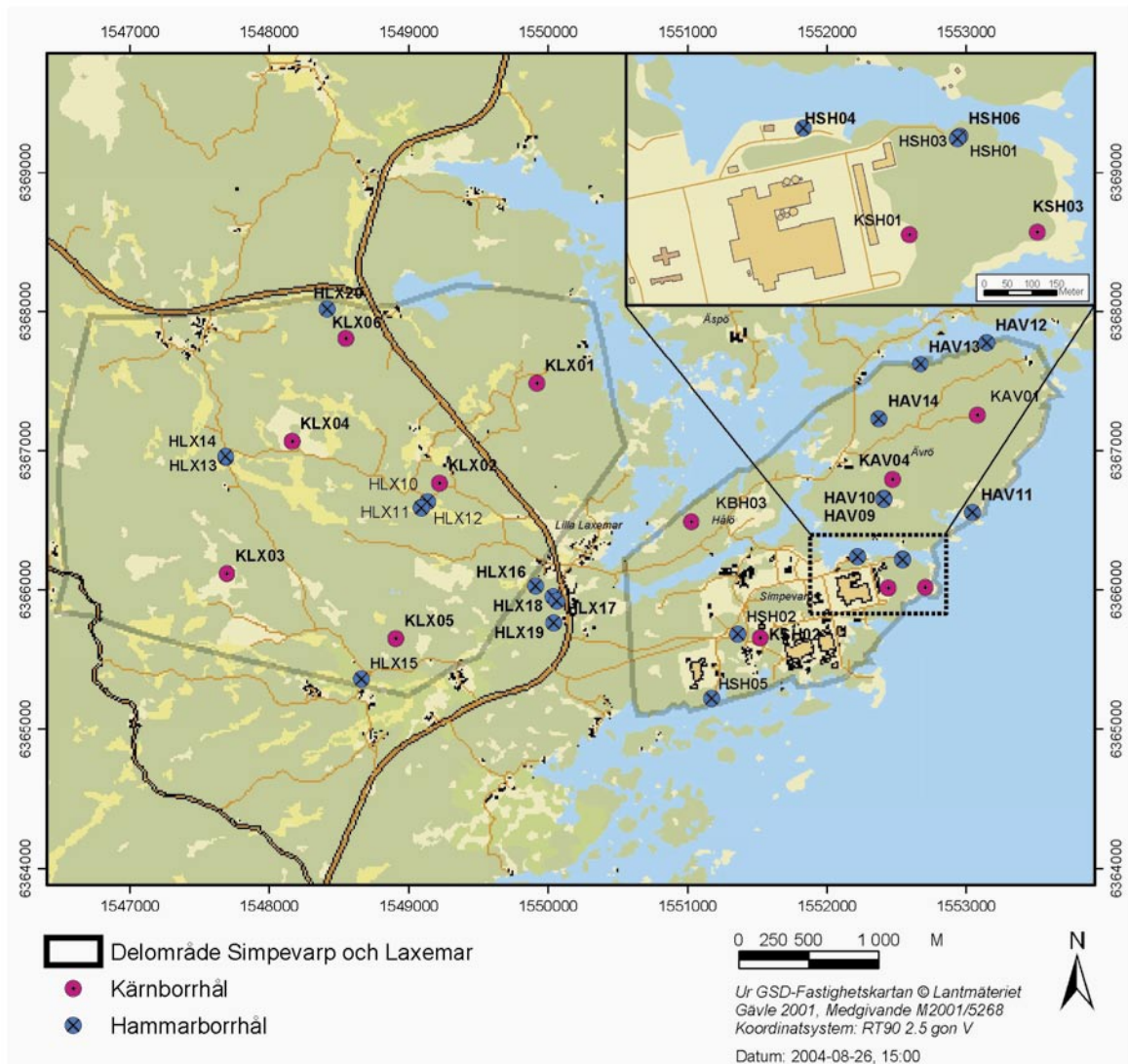


Figure 1-1. Location of the drill hole KLX03A at the Oskarshamn site investigation area.

2 Objective and scope

The purpose of the testing is to determine the density and porosity of intact rock core samples. 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 Oskarshamn.

The samples are taken from the borehole KLX03A in Laxemar, with a depth of about 1,000 m. The samples in this report are taken at three different main levels.

3 Equipment

Following equipment has been used for the analyses:

- Thermometer (inv no 102185) for measurement of water temperature. Calibrated 2005-02-04. Uncertainty of measurement $\pm 0.4^{\circ}\text{C}$.
- Scale (inv no 102291) for weight measurement. Calibrated in March 2004. Uncertainty of measurement ± 0.2 g.
- Heating chamber (inv no 102289) for drying the specimens. Calibrated 2004-08-31. Uncertainty of measurement $\pm 5^{\circ}\text{C}$.
- A covered plastic box filled with water for water saturation of the samples.
- A dessicator for cooling samples in.

Uncertainty of method as expanded uncertainty with covering factor 2 (95% confidence interval):

Density ± 4 kg/m³

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 160.002e (SKB internal controlling document). This includes determination of density in accordance to /ISRM, 1979/ and water saturation by /EN 13755/ and in accordance to Activity plan AP PS 400-04-106 (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 three levels in drill hole KLX03A. Level 1 ranges between 290 and 320 m, level 2 between 510 and 520 m and level 3 between 690 and 710 m. Table 4-1 shows the rock types and identification marks of the specimens.

Table 4-1. Rock types and identification marks (Rock-type classification according to the overview mapping).

| Identification | Sampling depth (Adj Seclow) | Rock types |
|----------------|--------------------------------|---------------------|
| KLX03A-90V-1 | 315.532 | Ävrö granite |
| KLX03A-90V-2 | 315.593 | Ävrö granite |
| KLX03A-90V-3 | 315.653 | Ävrö granite |
| KLX03A-90V-4 | 318.070 | Ävrö granite |
| KLX03A-90V-5 | 318.130 | Ävrö granite |
| KLX03A-90V-7 | 519.761 | Ävrö granite |
| KLX03A-90V-8 | 519.822 | Ävrö granite |
| KLX03A-90V-9 | 519.882 | Ävrö granite |
| KLX03A-90V-10 | 519.938 | Ävrö granite |
| KLX03A-90V-11 | 519.999 | Ävrö granite |
| KLX03A-90V-13 | 695.337 | Quartz monzodiorite |
| KLX03A-90V-14 | 695.391 | Quartz monzodiorite |
| KLX03A-90V-15 | 695.450 | Quartz monzodiorite |
| KLX03A-90V-16 | 695.512 | Quartz monzodiorite |
| KLX03A-90V-17 | 695.572 | Quartz monzodiorite |

4.2 Testing

The execution procedure followed the prescription in SKB MD 160.002e (SKB internal controlling document), see 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 determining 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 tapwater. |
| 4 | The specimens were surface dried with a towel and weighted. |
| 5 | The water saturated density was determined. The temperature of water was 19°C and the density of the water was 998 kg/m ³ . |
| 6 | The specimens were photographed in JPEG-format. |
| 7 | The samples were sent from 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°C. |
| 10 | The specimens were transported to a dessicator for cooling. |
| 11 | The dry density and porosity were determined. |

4.3 Nonconformities

None

5 Results

Data resulting from this activity are stored in the SKB database SICADA. Protocols, calculations and photos are presented in Appendix 1.

5.1 Summary of results

A summary of the results of the porosity and density determinations are presented in Tables 5-1, 5-2 and 5-3, 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 from level 1, secrow 290 to 320 m. The result for each specimen is a mean value of subsample A and B.

| Specimen | Sampling depth, according to the marks on the drill-core boxes (Adj Secrow) (m) | Porosity (%) | Dry density (kg/m ³) | Wet density (kg/m ³) |
|---------------------------|---|--------------|----------------------------------|----------------------------------|
| KLX03A-90V-1 | 315.532 | 0.2 | 2,770 | 2,780 |
| KLX03A-90V-2 | 315.593 | 0.2 | 2,760 | 2,770 |
| KLX03A-90V-3 | 315.653 | 0.2 | 2,770 | 2,770 |
| KLX03A-90V-4 | 318.070 | 0.2 | 2,760 | 2,760 |
| KLX03A-90V-5 | 318.130 | 0.2 | 2,770 | 2,770 |
| Mean value | | 0.2 | 2,770 | 2,770 |
| Standard deviation | | 0.0 | 9 | 9 |

Table 5-2. Summary of the results for porosity, dry density and wet density of the specimens from level 2, secrow 510 to 520 m. The result for each specimen is a mean value of subsample A and B.

| Specimen | Sampling depth, according to the marks on the drill-core boxes (Adj Secrow) (m) | Porosity (%) | Dry density (kg/m ³) | Wet density (kg/m ³) |
|---------------------------|---|--------------|----------------------------------|----------------------------------|
| KLX03A-90V-7 | 519.761 | 0.2 | 2,800 | 2,810 |
| KLX03A-90V-8 | 519.822 | 0.3 | 2,810 | 2,810 |
| KLX03A-90V-9 | 519.882 | 0.2 | 2,810 | 2,810 |
| KLX03A-90V-10 | 519.938 | 0.3 | 2,810 | 2,810 |
| KLX03A-90V-11 | 519.999 | 0.3 | 2,790 | 2,800 |
| Mean value | | 0.3 | 2,800 | 2,810 |
| Standard deviation | | 0.0 | 7 | 7 |

Table 5-3. Summary of the results for porosity, dry density and wet density of the specimens from level 3 seclow 690 m to 710 m. The result for each specimen is a mean value of subsample A and B.

| Specimen | Sampling depth, according to the marks on the drill-core boxes (Adj Seclow) (m) | Porosity (%) | Dry density (kg/m ³) | Wet density (kg/m ³) |
|---------------------------|---|--------------|----------------------------------|----------------------------------|
| KLX03A-90V-13 | 695.337 | 0.2 | 2,800 | 2,800 |
| KLX03A-90V-14 | 695.391 | 0.2 | 2,810 | 2,810 |
| KLX03A-90V-15 | 695.450 | 0.2 | 2,810 | 2,820 |
| KLX03A-90V-16 | 695.512 | 0.3 | 2,810 | 2,820 |
| KLX03A-90V-17 | 695.572 | 0.4 | 2,800 | 2,810 |
| Mean value | | 0.3 | 2,810 | 2,810 |
| Standard deviation | | 0.1 | 8 | 8 |

Dry density KLX03A

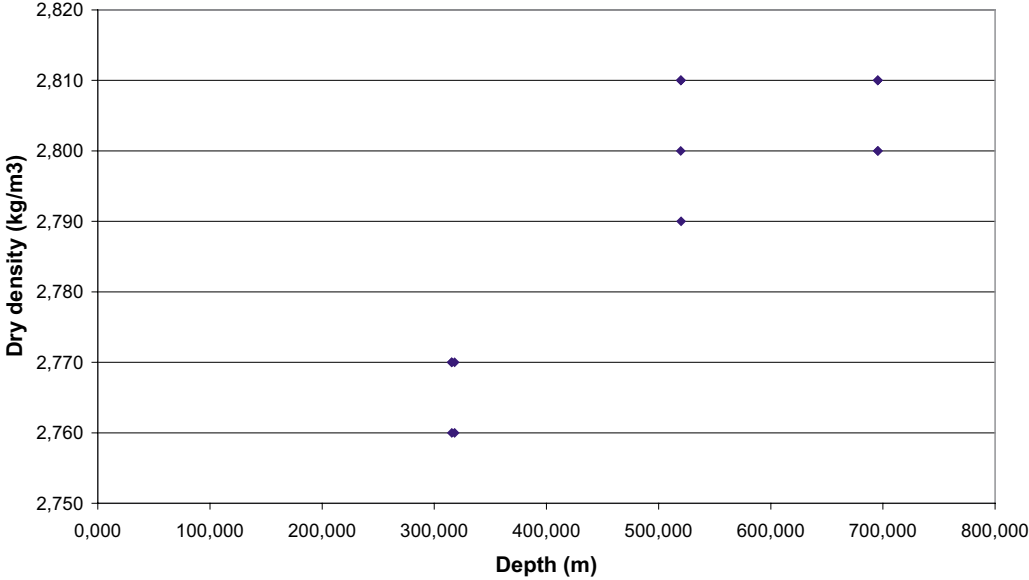


Figure 5-1. Density (dry) versus depth, depth is where the samples are taken in the borehole.

Wet Density KLX03A

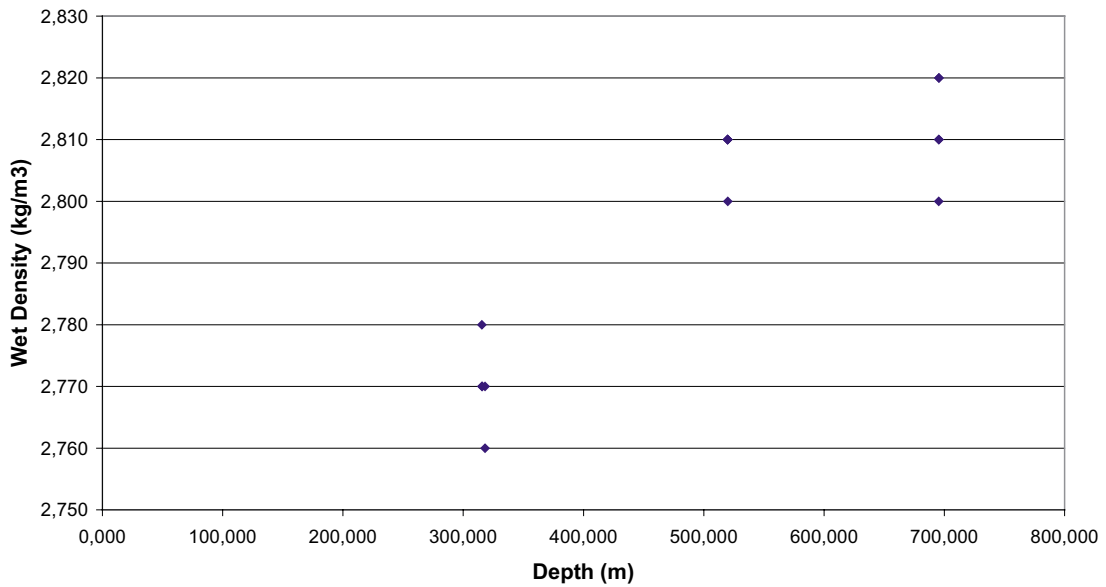


Figure 5-2. Density (wet) versus depth, depth is where the samples are taken in the borehole.

Porosity KLX03A

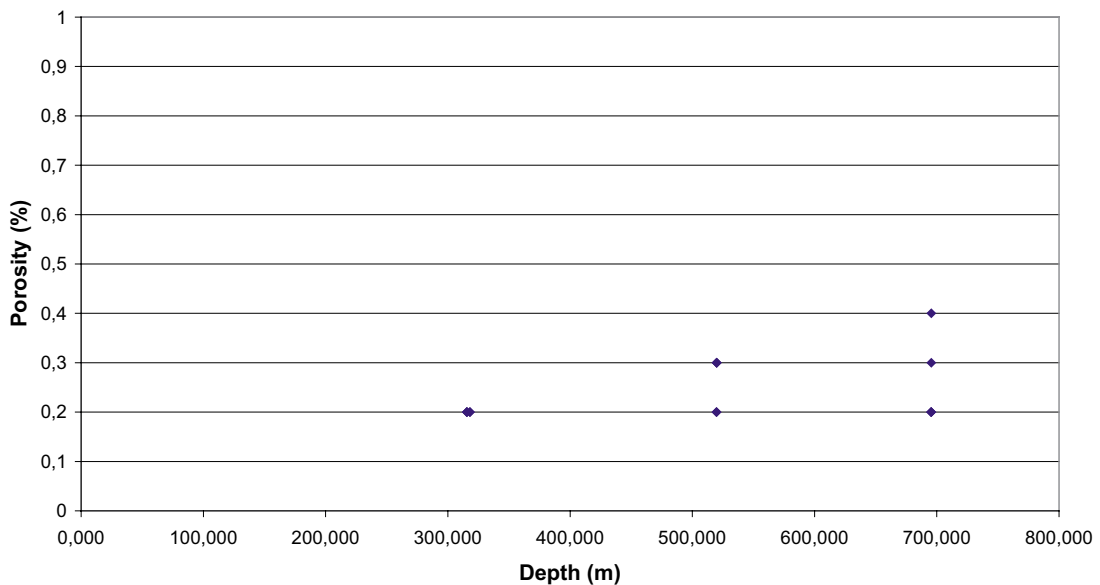


Figure 5-3. Porosity versus depth, depth is where the samples are taken in the borehole.

5.2 Discussion

The tests were performed in accordance with the method descriptions. Sample KLX03A-90V-17 and spare sample KLX03A-90V-18 cracked during testing. It was determined that the result from KLX03A-90V-17 will be used since the damage in this sample was smaller. The activity plan was otherwise followed without deviations.

References

ISRM 1979. Volume 16, Number 2.

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

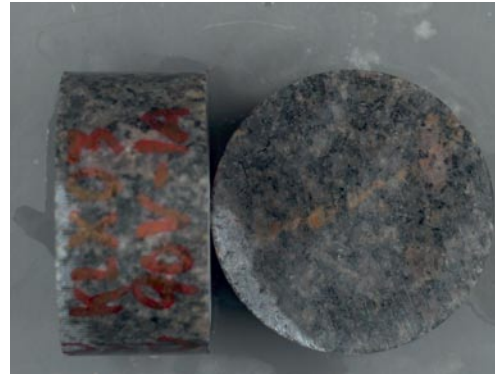
KLX03A: Density and porosity

Table 1. Level 1 290-320 m, Specimen KLX03A-090V-1 to KLX03A-090V-5.

KLX03A-90V-1 (315.532)

The dry density for specimen KLX03A-90V-1A was measured to be 2,770 kg/m³ and the porosity to 0.2% and the dry density for specimen KLX03A-90V-1B was measured to be 2,770 kg/m³ and the porosity to 0.2%.

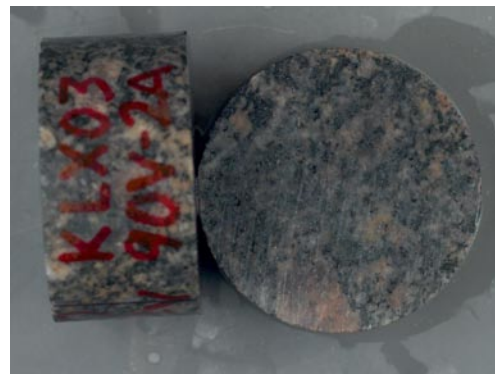
Figure 1. Specimen KLX03A-90V-1.



KLX03A-90V-2 (315.593)

The dry density for specimen KLX03A-90V-2A was measured to be 2,760 kg/m³ and the porosity to 0.2% and the dry density for specimen KLX03A-90V-2B was measured to be 2,760 kg/m³ and the porosity to 0.2%.

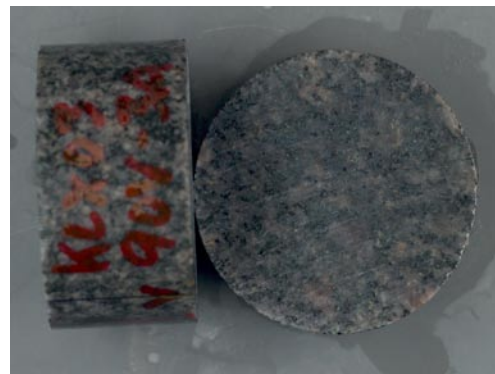
Figure 2. Specimen KLX03A-90V-2



KLX03A-90V-3 (315.653)

The dry density for specimen KLX03A-90V-3A was measured to be 2,770 kg/m³ and the porosity to 0.2% and the dry density for specimen KLX03A-90V-3B was measured to be 2,770 kg/m³ and the porosity to 0.2%.

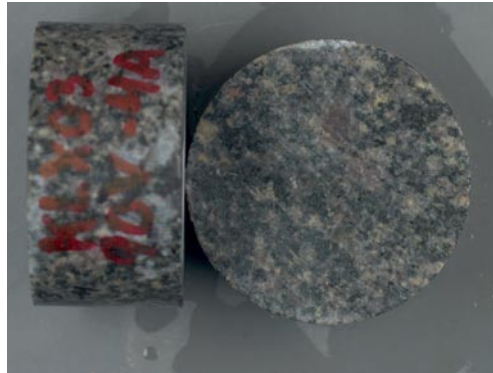
Figure 3. Specimen KLX03A-90V-3.



KLX03A-90V-4 (318.070)

The dry density for specimen KLX03A-90V-4A was measured to be 2,740 kg/m³ and the porosity to 0.2% and the dry density for specimen KLX03A-90V-4B was measured to be 2,770 kg/m³ and the porosity to 0.2%.

Figure 4. Specimen KLX03A-90V-4.



KLX03A-90V-5 (318.130)

The dry density for specimen KLX03A-90V-5A was measured to be 2,770 kg/m³ and the porosity to 0.2% and the dry density for specimen KLX03A-90V-5B was measured to be 2,760 kg/m³ and the porosity to 0.2%.

Figure 5. Specimen KLX03A-90V-5.

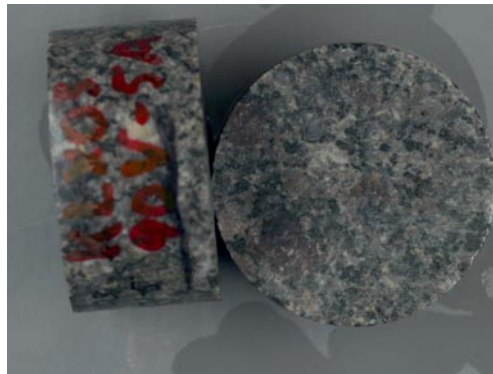


Table 2. Level 2 510-520 m, Specimen KLX03A-090V-7 to KLX03A-090V-12.

KLX03A-90V-7 (519.761)

The dry density for specimen KLX03A-90V-7A was measured to be 2,800 kg/m³ and the porosity to 0.2% and the dry density for specimen KLX03A-90V-7B was measured to be 2,800 kg/m³ and the porosity to 0.2%.

Figure 6. Specimen KLX03A-90V-7.



KLX03A-90V-8 (519.822)

The dry density for specimen KLX03A-90V-8A was measured to be 2,810 kg/m³ and the porosity to 0.3% and the dry density for specimen KLX03A-90V-8B was measured to be 2,810 kg/m³ and the porosity to 0.2%.

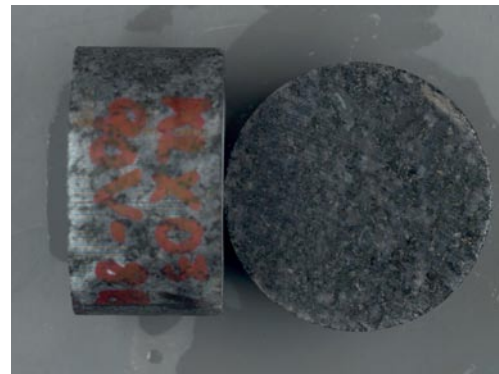
Figure 7. Specimen KLX03A-90V-8.



KLX03A-90V-9 (519.882)

The dry density for specimen KLX03A-90V-10A was measured to be 2,810 kg/m³ and the porosity to 0.3% and the dry density for specimen KLX03A-90V-10B was measured to be 2,810 kg/m³ and the porosity to 0.2%.

Figure 8. Specimen KLX03A-90V-9.



KLX03A-90V-10 (519.938)

The dry density for specimen KLX03A-90V-11A was measured to be 2,800 kg/m³ and the porosity to 0.3% and the dry density for specimen KLX03A-90V-11B was measured to be 2,810 kg/m³ and the porosity to 0.3%.

Figure 9. Specimen KLX03A-90V-10.



KLX03A-90V-11 (519.999)

The dry density for specimen KLX03A-90V-12A was measured to be 2,790 kg/m³ and the porosity to 0.3% and the dry density for specimen KLX03A-90V-12B was measured to be 2,790 kg/m³ and the porosity to 0.3%.

Figure 10. Specimen KLX03A-90V-11.

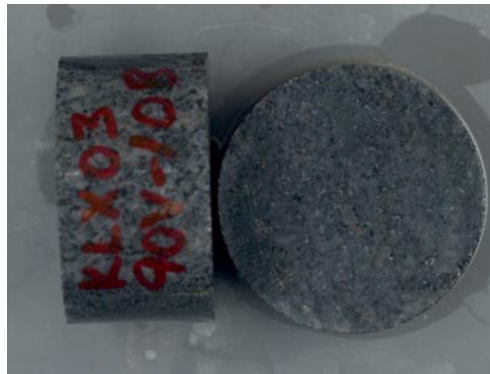
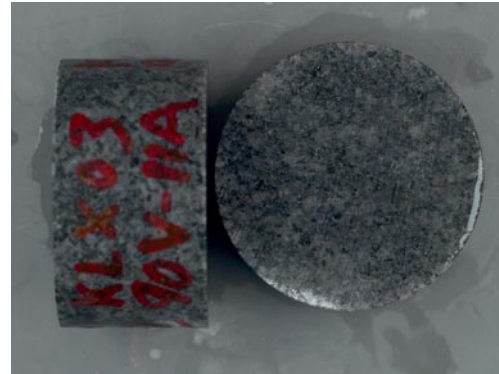


Table 3. Level 3 690-710 m, Specimen KLX03A-090V-13 to KLX03A-090V-17.

KLX03A-90V-13 (695.337)

Figure. 11. Specimen KLX03A-90V-13.

The dry density for specimen KLX03A-90V-13A was measured to be 2,810 kg/m³ and the porosity to 0.2% and the dry density for specimen KLX03A-90V-13B was measured to be 2,790 kg/m³ and the porosity to 0.2%.



KLX03A-90V-14 (695.391)

Figure. 12. Specimen KLX03A-90V-14.

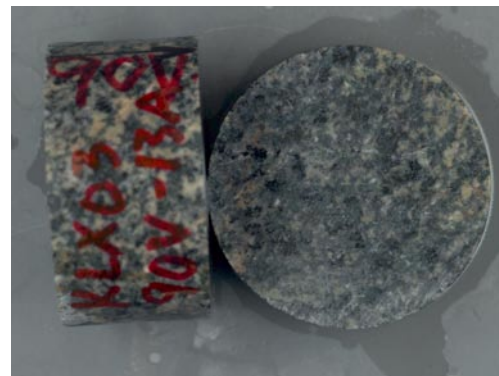
The dry density for specimen KLX03A-90V-14A was measured to be 2,800 kg/m³ and the porosity to 0.2% and the dry density for specimen KLX03A-90V-14B was measured to be 2,820 kg/m³ and the porosity to 0.2%.



KLX03A-90V-15 (695.450)

Figure. 13. Specimen KLX03A-90V-15.

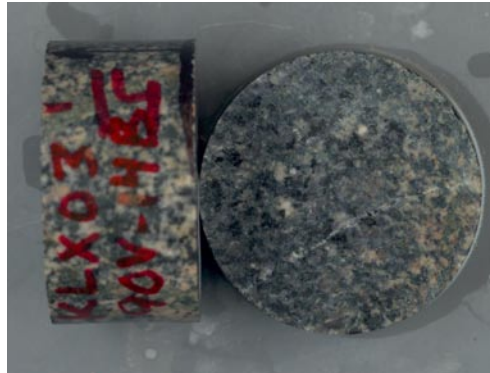
The dry density for specimen KLX03A-90V-15A was measured to be 2,810 kg/m³ and the porosity to 0.2% and the dry density for specimen KLX03A-90V-15B was measured to be 2,810 kg/m³ and the porosity to 0.2%.



KLX03A-90V-16 (695.512)

The dry density for specimen KLX03A-90V-16A was measured to be 2,820 kg/m³ and the porosity to 0.2% and the dry density for specimen KLX03A-90V-16B was measured to be 2,810 kg/m³ and the porosity to 0.3%.

Figure. 14. Specimen KLX03A-90V-16.



KLX03A-90V-17 (695.572)

The dry density for specimen KLX03A-90V-17A was measured to be 2,800 kg/m³ and the porosity to 0.4% and the dry density for specimen KLX03A-90V-17B was measured to be 2,790 kg/m³ and the porosity to 0.4%.

Figure. 15. Specimen KLX03A-90V-17.

