P-05-127

Oskarshamn site investigation

Drill hole KLX05AW

Determination of porosity by water saturation and density by buoyancy technique

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June 2005

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Keywords: Rock Mechanics, Petro Physics, Density, Porosity.

Abstract

The density and porosity has been determined on 24 specimens (each divided in two pieces) from drill hole KLX05A. The specimens were sampled on six different levels in the drill hole: level 1 220–245 m, level 2 290–300 m, level 3 340–370 m, level 4

410–420 m, level 5 490–590 m and level 6 470–650 m. The investigated rock types are mapped as granite for level 1, as ävrö granite for level 2 and 5, as gabbro for level 3, as fine grained diorite for level 4 and as quartz monzodiorite for level 6. The results for dry density varied between 2,670 and 3,010 kg/m^3, for wet density the results varied between 2,670 and 3,020 kg/m^3 and the results for porosity varied between 0.1 and 0.6%.

Sammanfattning

Densiteten och porositeten har bestämts på 24 provkroppar (varje provkropp delad i två delar) från borrhål KLX05A. Proverna togs från sex nivåer i borrhålet: nivå 1

220–245 m, nivå 2 290–300 m, nivå 3 340–370 m, nivå 4 410–420 m, nivå 5 440–460 m och nivå 6 490–590 m. De undersökta bergartstyperna är karterade som granit för nivå 1, Ävrö granit för nivå 2 och 5, gabbro för nivå 3, finkornig dioritoid för nivå 4 och kvartsmonzodiorit för nivå 6. Resultaten för den torra densiteten varierade mellan 2 670 och 3 010 kg/m^3, den våta densiteten varierade resultaten mellan 2 670 och 3 020 kg/m^3 och resultaten för porositeten varierade mellan 0,1 och 0,6 %.

Contents

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 KLX05A in the Oskarshamn area. Thomas Janson and Björn Ljunggren, Tyréns AB, sampled them 31 March 2005. Specimens were taken from 6 levels in the rock core, level 1 220–245 m, level 2 290–300 m, level 3 340–370 m, level 4 410–420 m, level 5 490–590 m and level 6 470–650 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 Oskarshamn and arrived to SP April 2005. The testing was started in April 2005 and ended in June 2005.

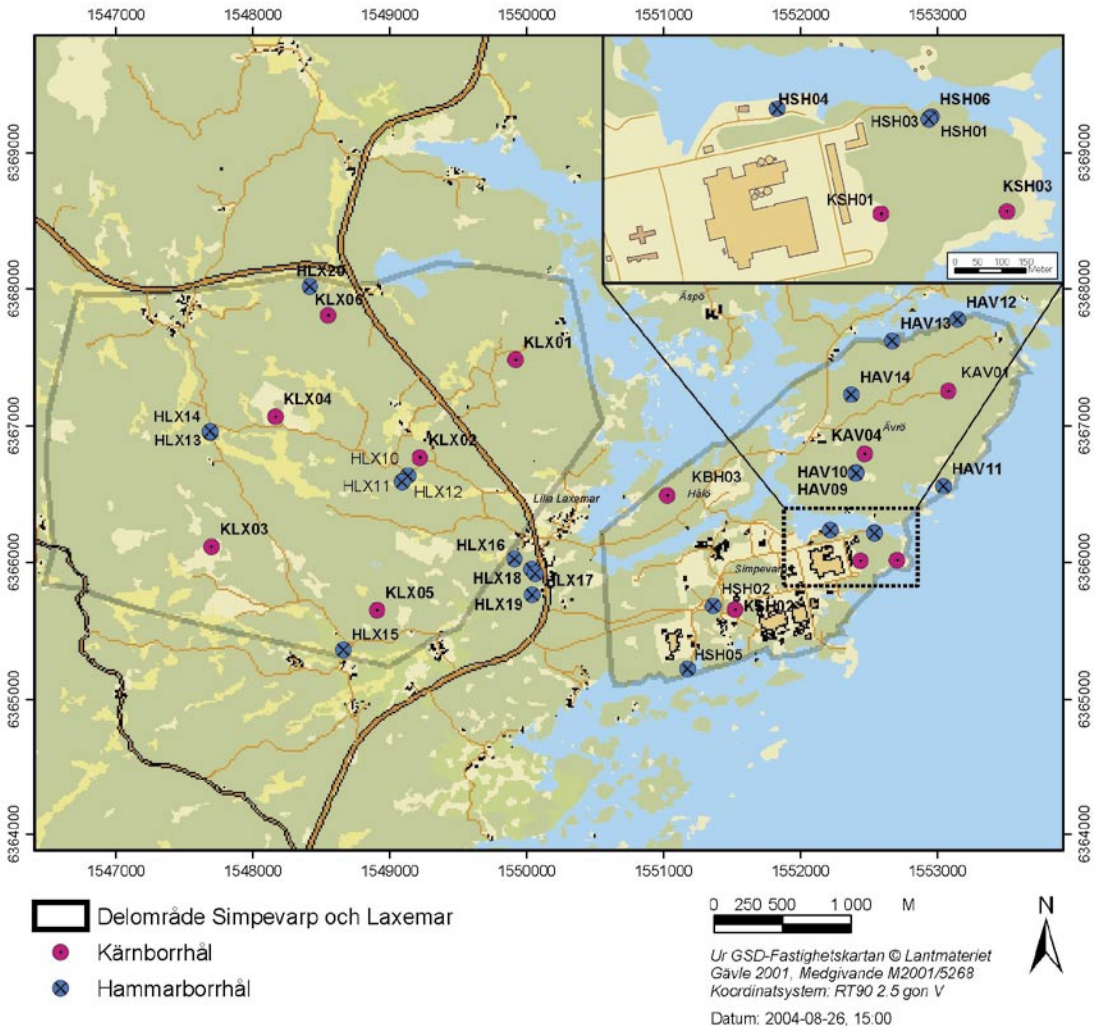


Figure 1-1. *Location of the drill hole KLX05A at the Oskarshamn site investigation area.*

2 Objective and scope

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

The samples are taken from the borehole KLX05A in Oskarhamn, with a depth of about 1,000 m. The samples in this report are taken from six 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 ± 0.4°C .
- Scale (inv no 102291) for weight measurement. Calibrated in 2005-03-02. 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 dessicator for cooling samples in

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 accordance to ISRM 1979 and EN 13755 in accordance to Activity plan AP PS 400-05-028 (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 six levels in drill hole KLX05A. Level 1 ranged between 220–245 m, level 2 290–300 m, level 3 340–370 m, level 4 410–420 m, level 5 490–590 m and level 6 470–650 m. 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 the overview mapping).

Identification	Sampling depth (Adj Seclow)	Rock type
KLX05A-90V-1	223.28	Granite
KLX05A -90V-2	233.50	Granite
KLX05A -90V-4	243.06	Granite
KLX05A -90V-5	292.49	Ävrö granite
KLX05A -90V-7	300.62	Ävrö granite
KLX05A -90V-8	340.71	Gabbro
KLX05A -90V-9	349.56	Gabbro
KLX05A-90V-10	361.31	Gabbro
KLX05A-90V-11	371.73	Gabbro
KLX05A-90V-12	408.35	Fine grained diorite
KLX05A-90V-13	413.55	Fine grained diorite
KLX05A-90V-15	417.47	Fine grained diorite
KLX05A-90V-16	444.32	Ävrö granite
KLX05A-90V-17	450.00	Ävrö granite
KLX05A-90V-18	461.23	Ävrö granite
KLX05A-90V-19	495.56	Quartz monzodiorite
KLX05A-90V-20	508.42	Quartz monzodiorite
KLX05A-90V-21	520.67	Quartz monzodiorite
KLX05A-90V-22	530.79	Quartz monzodiorite
KLX05A-90V-23	543.24	Quartz monzodiorite
KLX05A-90V-24	553.42	Quartz monzodiorite
KLX05A-90V-25	565.74	Quartz monzodiorite
KLX05A-90V-26	574.22	Quartz monzodiorite
KLX05A-90V-27	588.09	Quartz monzodiorite

4.2 Testing

The execution procedure followed the prescription in SKB MD 160.002, (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 determing 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 for water saturation was 20.2°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.

5 Results

Data resulting from activity are stored in the SKB database SICADA. Protocols, calculations and pictures can be found in Appendix 1.

5.1 Summary of results

A summary of the results of the porosity and density determination are presented in Table 5-1, 5-2, 5-3, 5-4, 5-5 and 5-6. The results are also shown in Figure 5-1, 5-2 and 5-3 below.

Table 5-1. Summary of the results for porosity, dry and wet density, for the specimens from level 1, seclow 220 m to 245 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 (Adj Seclow), (m)	Porosity (%)	Dry density (kg/m^3)	Wet density (kg/m^3)
KLX05A-90V-1	223.28	0.4	2,680	2,680
KLX05A-90V-2	233.50	0.4	2,670	2,670
KLX05A-90V-4	243.06	0.5	2,670	2,670
Mean value		0.4	2,670	2,670
Standard deviation		0.04	6	5

Table 5-2. Summary of the results for porosity, dry and wet density, for the specimens from level 2 seclow 290 m to 300 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 (Seclow) (m)	Porosity (%)	Dry density (kg/m^3)	Wet density (kg/m^3)
KLX05A-90V-5	292.49	0.6	2,720	2,720
KLX05A-90V-7	300.62	0.6	2,710	2,720
Mean value		0.6	2,710	2,720
Standard deviation		0.02	2	2

Table 5-3. Summary of the results for porosity, dry and wet density, for the specimens from level 3 seclow 340 m to 370 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 (Seclow) (m)	Porosity (%)	Dry density (kg/m^3)	Wet density (kg/m^3)
KLX05A-90V-8	340.71	0.2	2,910	2,910
KLX05A-90V-9	349.56	0.2	2,910	2,910
KLX05A-90V-10	361.31	0.2	3,010	3,020
KLX05A-90V-11	371.73	0.2	2,920	2,920
Mean value		0.2	2,940	2,940
Standard deviation		0.02	48	48

Table 5-4. Summary of the results for porosity, dry and wet density, for the specimens from level 4 seclow 410 m to 420 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 (Seclow) (m)	Porosity (%)	Dry density (kg/m^3)	Wet density (kg/m^3)
KLX05A-90V-12	408.35	0.2	2,960	2,960
KLX05A-90V-13	413.55	0.3	3,010	3,010
KLX05A-90V-15	417.47	0.3	2,970	2,970
Mean value		0.3	2,980	2,980
Standard deviation		0.05	24	24

Table 5-5. Summary of the results for porosity, dry and wet density, for the specimens from level 5 seclow 440 m to 460 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 (Seclow) (m)	Porosity (%)	Dry density (kg/m^3)	Wet density (kg/m^3)
KLX05A-90V-16	444.32	0.5	2,730	2,740
KLX05A-90V-17	450.00	0.4	2,740	2,750
KLX05A-90V-18	461.23	0.4	2,720	2,730
Mean value		0.4	2,730	2,740
Standard deviation		0.05	8	8

Table 5-6. Summary of the results for porosity, dry density and wet density, of the specimens from level 6 seclow 490 m to 590 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 (Seclow) (m)	Porosity (%)	Dry density (kg/m³)	Wet density (kg/m³)
KLX05A-90V-19	495.56	0.2	2,900	2,900
KLX05A-90V-20	508.42	0.1	2,880	2,890
KLX05A-90V-21	520.67	0.2	2,790	2,790
KLX05A-90V-22	530.79	0.2	2,780	2,780
KLX05A-90V-23	543.24	0.2	2,770	2,780
KLX05A-90V-24	553.42	0.3	2,780	2,780
KLX05A-90V-25	565.74	0.4	2,770	2,780
KLX05A-90V-26	574.22	0.3	2,780	2,780
KLX05A-90V-27	588.09	0.3	2,790	2,800
Mean value		0.3	2,810	2,810
Standard deviation		0.09	48	48

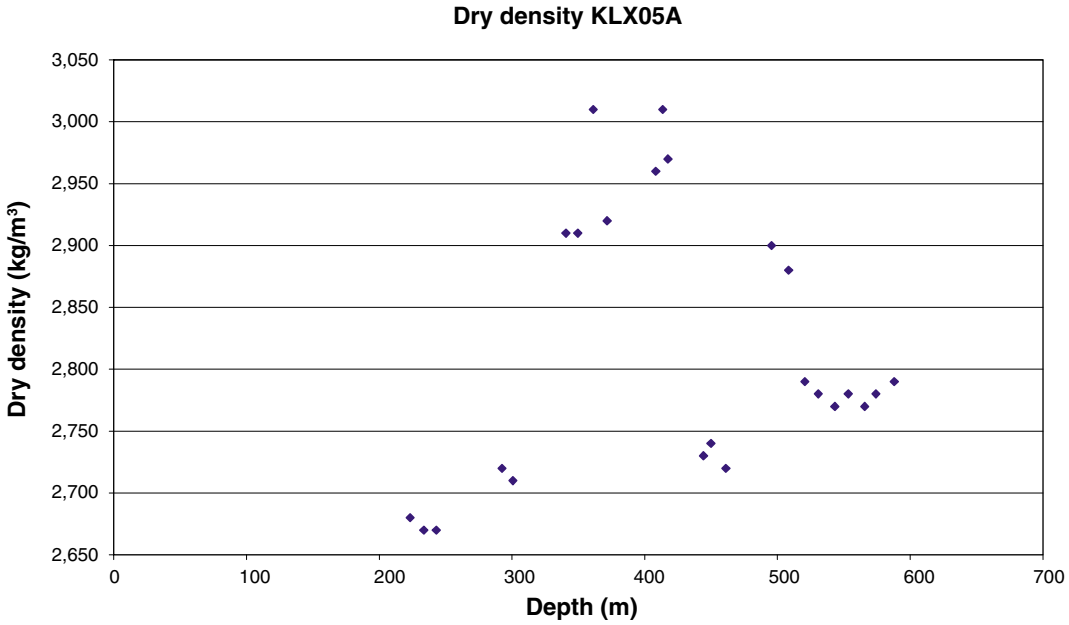


Figure 5-1. *Density (dry) versus depth, where the samples are taken in the borehole.*

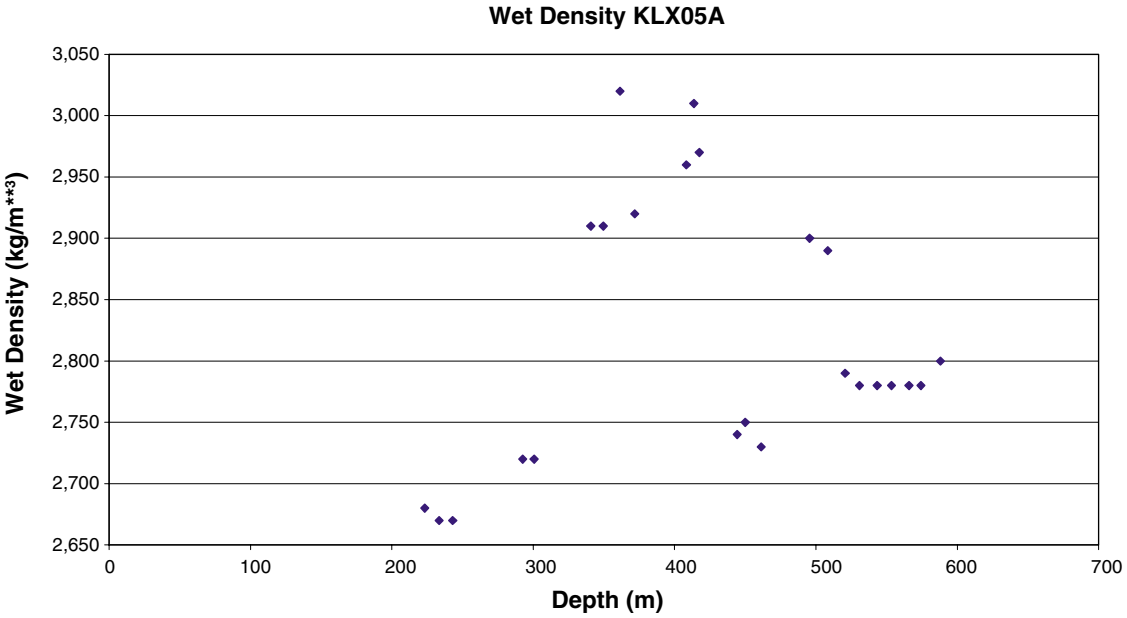


Figure 5-2. *Density (wet) versus depth, where the samples are taken in the borehole.*

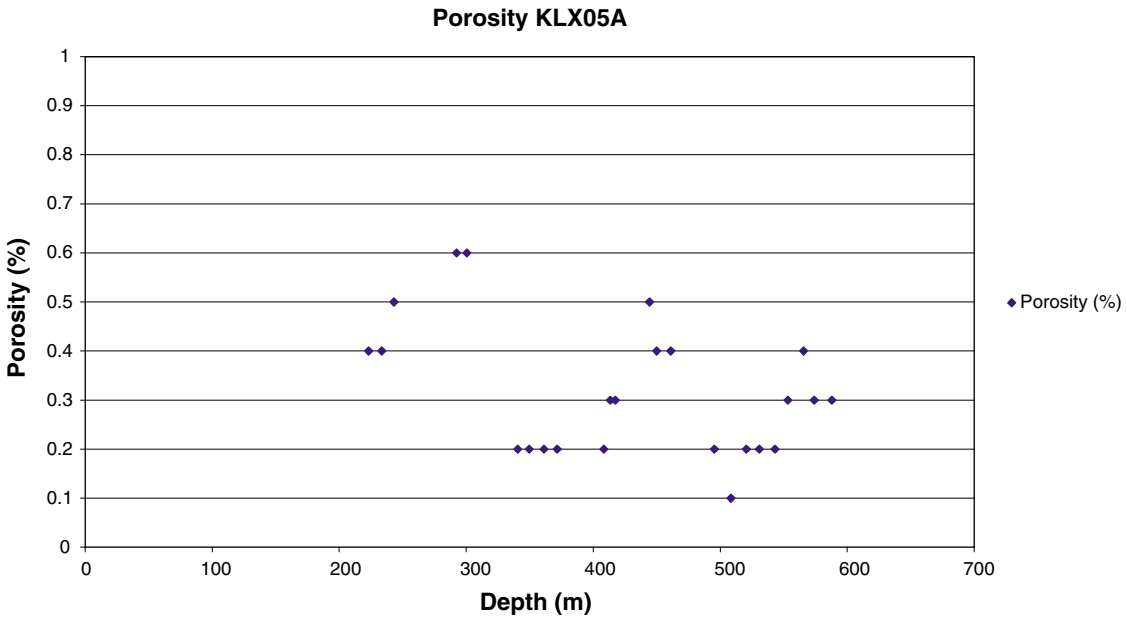


Figure 5-3. *Porosity versus depth, where the samples are taken in the borehole.*

5.2 Discussion

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

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

Table A-1. Level 1 210–290 m, Specimen KLX05A-090V-1 to KLX05A-090V-4.

KLX05A-90V-1 (223.28) The dry density for specimen KLX05A-90V-1A was measured to be 2,680 kg/m^3 and the porosity to 0.4% and the dry density for specimen KLX05A-90V-1B was measured to be 2,680 kg/m^3 and the porosity to 0.4%.	***Figure A-1.*** *Specimen KLX05A-90V-1.* 
KLX05A-90V-2 (233.50) The dry density for specimen KLX05A-90V-2A was measured to be 2,670 kg/m^3 and the porosity to 0.4% and the dry density for specimen KLX05A-90V-2B was measured to be 2,660 kg/m^3 and the porosity to 0.4%.	***Figure A-2.*** *Specimen KLX05A-90V-2* 
KLX05A-90V-4 (243.06) The dry density for specimen KLX05A-90V-4A was measured to be 2,670 kg/m^3 and the porosity to 0.4% and the dry density for specimen KLX05A-90V-4B was measured to be 2,670 kg/m^3 and the porosity to 0.5%.	***Figure A-3.*** *Specimen KLX05A-90V-4.* 

Table A-2. Level 2 290–300 m, Specimen KLX05A-090V-5 to KLX05A-090V-7.

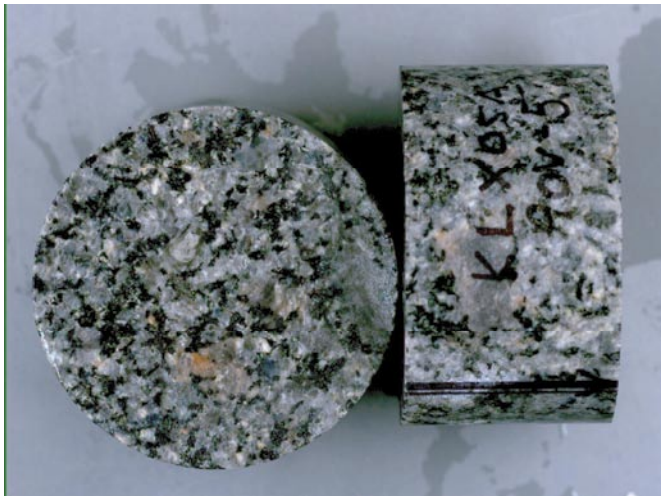
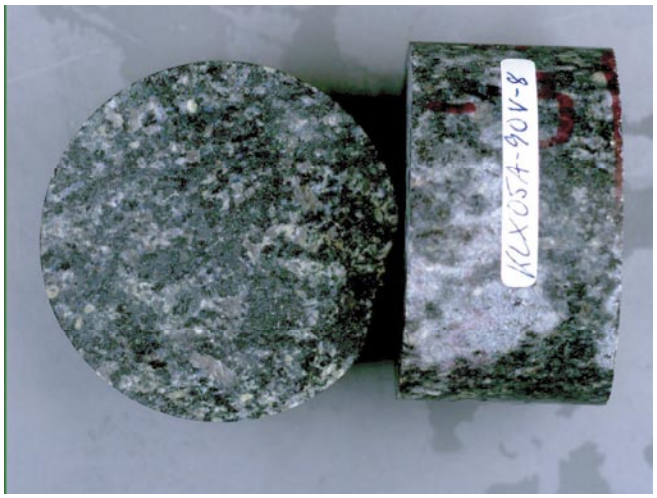
KLX05A-90V-5 (292.49) The dry density for specimen KLX05A-90V-5A was measured to be 2,720 kg/m^3 and the porosity to 0.6% and the dry density for specimen KLX05A-90V-5B was measured to be 2,720 kg/m^3 and the porosity to 0.6%.	***Figure A-4.*** *Specimen KLX05A-90V-5.* 
KLX05A-90V-7 (300.62) The dry density for specimen KLX05A -90V-7A was measured to be 2,710 kg/m^3 and the porosity to 0.6% and the dry density for specimen KLX05A-90V-7B was measured to be 2,710 kg/m^3 and the porosity to 0.6%.	***Figure A-5.*** *Specimen KLX05A-90V-7.* 

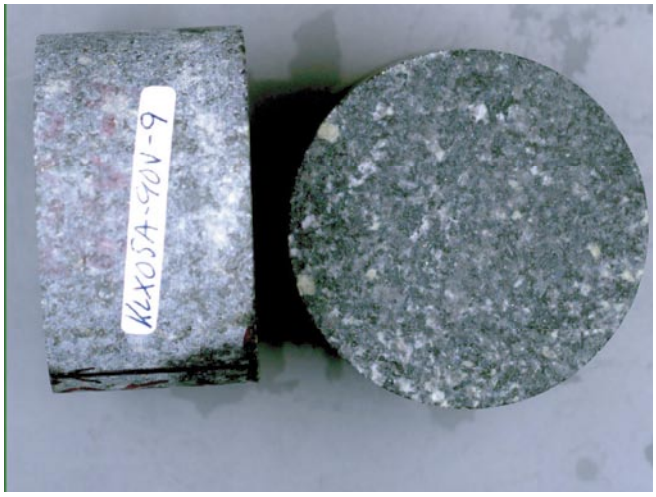
Table A-3. Level 3 340–370 m, Specimen KLX05A-090V-8 to KLX05A-090V-11.

KLX05A-90V-8 (340.71) The dry density for specimen KLX05A-90V-8A was measured to be 2,900 kg/m^3 and the porosity to 0.2% and the dry density for specimen KLX05A-90V-8B was measured to be 2,910 kg/m^3 and the porosity to 0.2%.	***Figure A-6.*** *Specimen KLX05A-90V-8.* 

KLX05A-90V-9 (349.56)

The dry density for specimen KLX05A-90V-9A was measured to be 2,900 kg/m^3 and the porosity to 0.2% and the dry density for specimen KLX05A-90V-9B was measured to be 2,910 kg/m^3 and the porosity to 0.2%.

Figure A-7. *Specimen KLX05A-90V-9.*



KLX05A-90V-10 (361.31)

The dry density for specimen KLX05A-90V-10A was measured to be 3,010 kg/m^3 and the porosity to 0.2% and the dry density for specimen KLX05A-90V-10B was measured to be 3,010 kg/m^3 and the porosity to 0.2%.

Figure A-8. *Specimen KLX05A-90V-10.*

KLX05A-90V-11 (371.73)

The dry density for specimen KLX05A-90V-11A was measured to be 2,920 kg/m^3 and the porosity to 0.2% and the dry density for specimen KLX05A-90V-11B was measured to be 2,910 kg/m^3 and the porosity to 0.2%.

Figure A-9. *Specimen KLX05A-90V-11.*

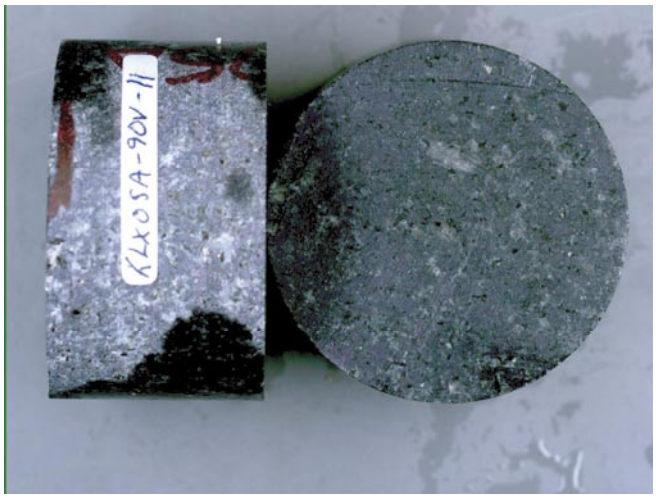


Table A-4. Level 4 410–420 m, Specimen KLX05A-090V-12 to KLX05A-090V-15.

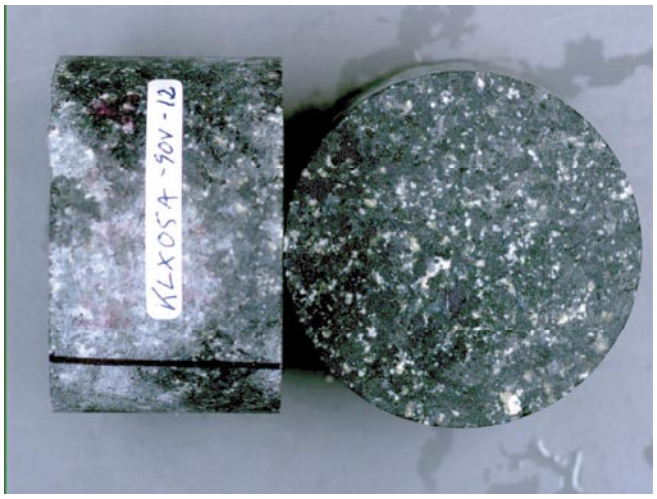
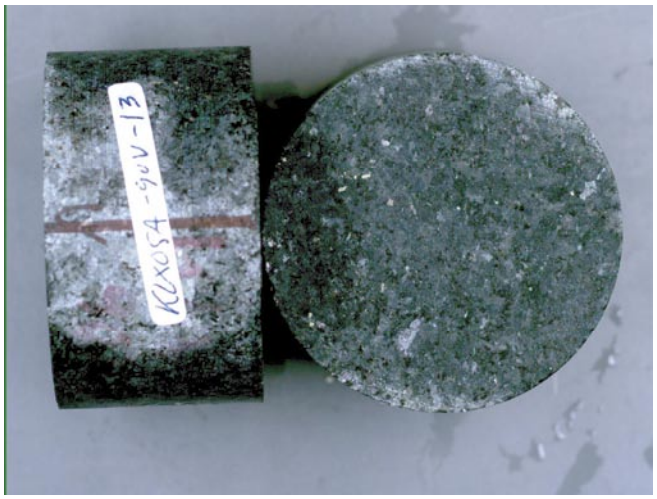
KLX05A-90V-12 (408.35) The dry density for specimen KLX05A-90V-12A was measured to be 2,950 kg/m^3 and the porosity to 0.2% and the dry density for specimen KLX05A-90V-12B was measured to be 2,960 kg/m^3 and the porosity to 0.2%.	***Figure A-10.*** *Specimen KLX05A-90V-12.* 
KLX05A-90V-13 (413.55) The dry density for specimen KLX05A-90V-13A was measured to be 3,010 kg/m^3 and the porosity to 0.3% and the dry density for specimen KLX05A-90V-13B was measured to be 3,010 kg/m^3 and the porosity to 0.2%.	***Figure A-11.*** *Specimen KLX05A-90V-13.* 
KLX05A-90V-15 (417.47) The dry density for specimen KLX05A-90V-15A was measured to be 2,970 kg/m^3 and the porosity to 0.3% and the dry density for specimen KLX05A-90V-15B was measured to be 2,970 kg/m^3 and the porosity to 0.3%.	***Figure A-12.*** *Specimen KLX05A-90V-15.* 

Table A-5. Level 5 440–460 m, Specimen KLX05A-090V-16 to KLX05A-090V-18.

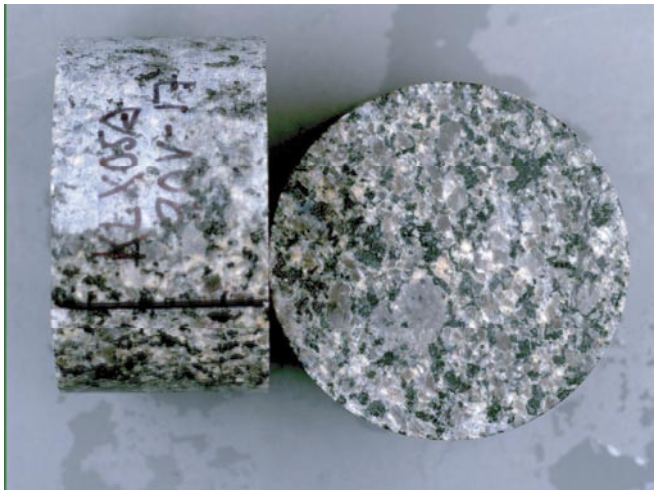
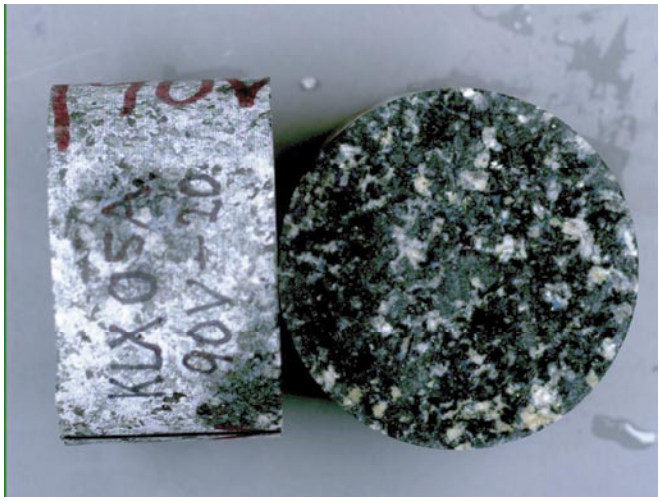
KLX05A-90V-16 (444.32) The dry density for specimen KLX05A-90V-16A was measured to be 2,730 kg/m^3 and the porosity to 0.5% and the dry density for specimen KLX05A-90V-16B was measured to be 2,730 kg/m^3 and the porosity to 0.5%.	***Figure A-13.*** *Specimen KLX05A-90V-16.* 
KLX05A-90V-17 (450.00) The dry density for specimen KLX05A-90V-17A was measured to be 2,740 kg/m^3 and the porosity to 0.4% and the dry density for specimen KLX05A-90V-17B was measured to be 2,740 kg/m^3 and the porosity to 0.4%.	***Figure A-14.*** *Specimen KLX05A-90V-17.* 
KLX05A-90V-18 (461.23) The dry density for specimen KLX05A-90V-18A was measured to be 2,730 kg/m^3 and the porosity to 0.4% and the dry density for specimen KLX05A-90V-18B was measured to be 2,720 kg/m^3 and the porosity to 0.4%.	***Figure A-15.*** *Specimen KLX05A-90V-18.* 

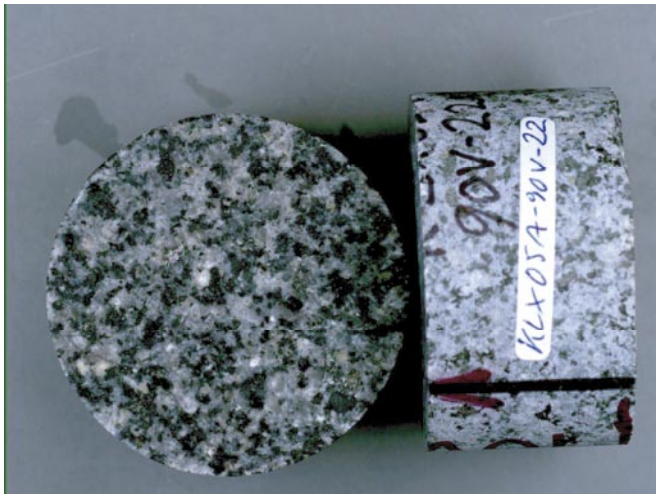
Table A-6. Level 6 470–650 m, Specimen KLX05A-090V-19 to KLX05A-090V-27.

KLX05A-90V-19 (495.56) The dry density for specimen KLX05A-90V-19A was measured to be 2,900 kg/m^3 and the porosity to 0.2% and the dry density for specimen KLX05A-90V-19B was measured to be 2,900 kg/m^3 and the porosity to 0.1%.	***Figure A-16.*** *Specimen KLX05A-90V-19.* 
KLX05A-90V-20 (508.42) The dry density for specimen KLX05A-90V-20A was measured to be 2,890 kg/m^3 and the porosity to 0.1% and the dry density for specimen KLX05A-90V-20B was measured to be 2,880 kg/m^3 and the porosity to 0.2%.	***Figure A-17.*** *Specimen KLX05A-90V-20.* 
KLX05A-90V-21 (520.67) The dry density for specimen KLX05A-90V-21A was measured to be 2,800 kg/m^3 and the porosity to 0.2% and the dry density for specimen KLX05A-90V-21B was measured to be 2,780 kg/m^3 and the porosity to 0.2%.	***Figure A-18.*** *Specimen KLX05A-90V-21.* 

KLX05A-90V-22 (530.79)

The dry density for specimen KLX05A-90V-22A was measured to be 2,780 kg/m^3 and the porosity to 0.2% and the dry density for specimen KLX05A-90V-22B was measured to be 2,780 kg/m^3 and the porosity to 0.2%.

Figure A-19. *Specimen KLX05A-90V-22.*



KLX05A-90V-23 (543.24)

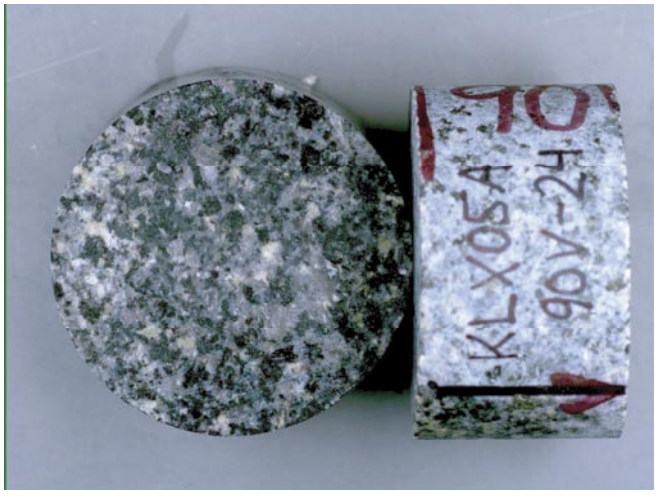
The dry density for specimen KLX05A-90V-23A was measured to be 2,770 kg/m^3 and the porosity to 0.3% and the dry density for specimen KLX05A-90V-23B was measured to be 2,780 kg/m^3 and the porosity to 0.2%.

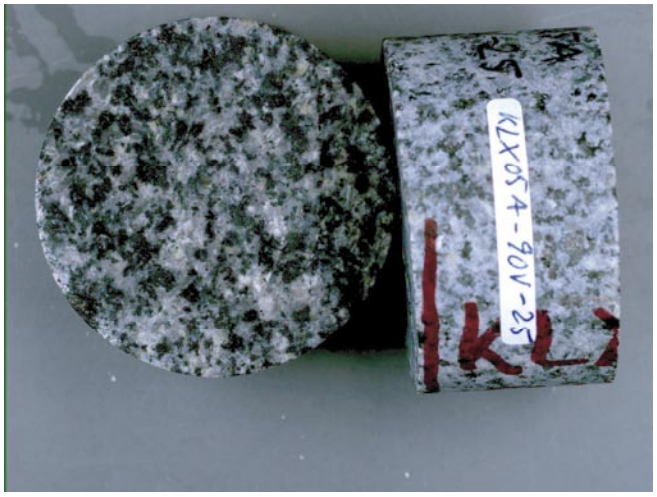
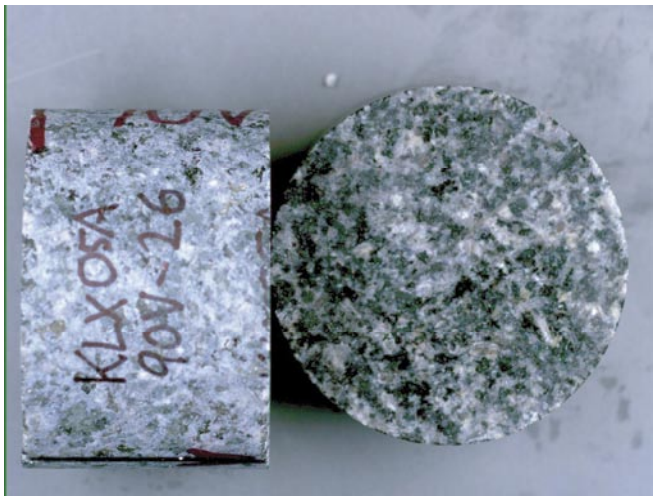
Figure A-20. *Specimen KLX05A-90V-23.*

KLX05A-90V-24 (553.42)

The dry density for specimen KLX05A-90V-24A was measured to be 2,780 kg/m^3 and the porosity to 0.2% and the dry density for specimen KLX05A-90V-24B was measured to be 2,770 kg/m^3 and the porosity to 0.3%.

Figure A-21. *Specimen KLX05A-90V-24.*



KLX05A-90V-25 (565.74) The dry density for specimen KLX05A-90V-25A was measured to be 2,780 kg/m^3 and the porosity to 0.4% and the dry density for specimen KLX05A-90V-25B was measured to be 2,770 kg/m^3 and the porosity to 0.4%.	***Figure A-22.*** *Specimen KLX05A-90V-25.* 
KLX05A-90V-26 (574.22) The dry density for specimen KLX05A-90V-26A was measured to be 2,780 kg/m^3 and the porosity to 0.3% and the dry density for specimen KLX05A-90V-26B was measured to be 2,780 kg/m^3 and the porosity to 0.3%.	***Figure A-23.*** *Specimen KLX05A-90V-26.* 
KLX05A-90V-27 (588.09) The dry density for specimen KLX05A-90V-27A was measured to be 2,790 kg/m^3 and the porosity to 0.3% and the dry density for specimen KLX05A-90V-27B was measured to be 2,790 kg/m^3 and the porosity to 0.3%.	***Figure A-24.*** *Specimen KLX05A-90V-27.*