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Appendix A: Drill Core Analysis Report

Giant Mine Freeze Optimization Study – Drill Core Analysis Report

Report Prepared for

Public Works and Government Services Canada

Report Prepared by

srk consulting

SENES Consultants Limited

SRK Consulting (Canada) Inc.
1CS019.018
November 2011

Giant Mine Freeze Optimization Study – Drill Core Analysis Report

Public Works and Government Services Canada

5101 - 50th Avenue, P.O. Box 518, Greenstone Building
Yellowknife, NT X1A 2N4

SRK Consulting (Canada) Inc.
Suite 2200 – 1066 West Hastings Street
Vancouver, BC V6E 3X2

e-mail: vancouver@srk.com
website: www.srk.com

Tel: +1.604.681.4196
Fax: +1.604.687.5532

SRK Project Number 1CS019.018
November 2011

Authors:
Arlene Laudrum, P.Geol.
Senior Consultant

Peter Mikes, P.Eng.
Senior Consultant

Kirsty Ketchum, P.Geol.
Consultant

Peer Reviewed by:
Dan Hewitt
Principal Consultant

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1 Introduction

The Freeze Optimization Study (FOS) is being carried out to determine the optimal freeze method for the full freeze program and its design parameters. The FOS is being conducted at Chamber 10, one of the arsenic dust containing chambers near C-Shaft. The FOS monitors several combinations of active freezing, passive freezing and hybrid freezing systems.

Rock compositions and mineralogy distribution are important factors that are considered in the thermal modeling used for assessing performance. Differences in the mineralogy of the rock around Chamber 10 can lead to significant differences in thermal properties. In order to avoid those differences confounding the interpretation of the FOS data, a mineralogical analysis of the core was completed.

Drill core was retrieved from eleven boreholes around Chamber 10 for the dual purposes of geotechnical assessment and determining thermal properties of the rock. The geotechnical report was submitted with the FOS interim as-built report (SRK 2009). This report analyzes the mineralogy of core samples collected from around Chamber 10 and determines a representative range of thermal bedrock properties for thermal modeling and evaluation of the FOS.

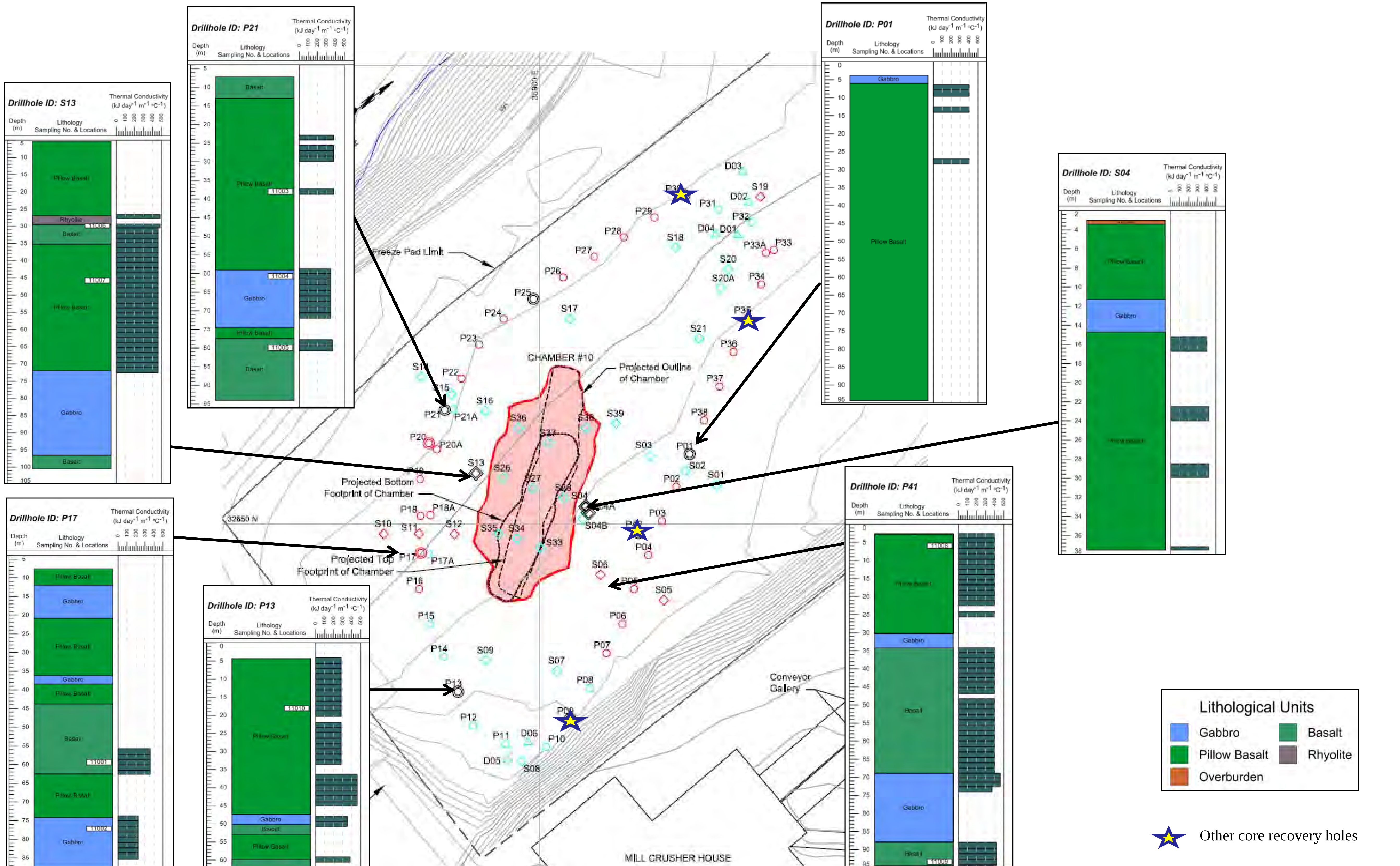
2 Drill Core Inspection

Seven boreholes were logged for geological properties between February and April 2011 by Arlene Laudrum at the Giant Mine site. The holes were selected for logging based on their relation to Chamber 10 and the regional trend of the rocks. Figure 1 provides the location of the logged boreholes as well as a summary of the lithological units encountered in each hole. Boreholes P01, P41, and S04 east of the chamber are located on a hanging wall. Boreholes P17, P21 and S13 located west of the chamber are located in the footwall. Borehole P13 is located along the strike of the chamber.

The lithology, structure, alteration and mineralization were logged for the entire length core. At 1.5 m intervals, the intensity of chlorite, silica, carbonate alteration, epitdote/quartz/carbonate veining and flooding, as well as the percentage of veining and mineralization were logged.

Samples were selected for mineralogical analyses that were representative of the predominant lithologies observed and their common forms of alteration. A comparison to previous samples collected was made as the core logging progressed. Results of the geological logging are presented in Appendix A.

Chamber 10 is located within north trending altered metavolcanic rocks. The rocks dip steeply towards the east. The rock surrounding the chamber consists of a succession of massive and pillowed basaltic flows that are intercalated with coarse grained gabbro dykes. The basalt grades from fine grained to medium grained. The rock exhibits variably foliated alteration zones. Epidote and chlorite alteration was observed to be stronger in the hanging wall rock on the west side of the chamber.



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Indian and Northern Affairs Canada / Affaires Indiennes et du Nord Canada

Public Works and Government Services Canada / Travaux publics et services gouvernementaux Canada

FOS Drill Core Analysis

Bedrock Lithology and Thermal Conductivities

Giant Mine

Job No: 1CS019.018.001

Filename: Figure1.FOSThermalK.1CS19.018.pm.rev02.pptx

Date: Aug. 8, 2011

Approved: PHM

Figure: 1

3 Mineralogical Analysis

Eleven 5 cm x 5 cm thin sections were prepared by Vancouver Petrographics, from samples of drill core selected by Arlene Laudrum. Thin sections were analysed May 30th to June 2nd by Kirsty Ketchum, at the NT Geoscience Office, using their transmitted light microscope with x2, x10, x20 and x50 magnification and both plane polarized light (PPL) and crossed polarized light (XPL). Photographs were taken of the thin sections (photomicrographs) using the digital camera attached to the microscope. The field of view for the photomicrographs at each magnification photographed is as follows: X2 = 4.5 mm, x10 = 1.1 mm, x20 = 0.75 mm. Table 3.1 summarizes the notes and observations of samples with references to the photomicrographs that are included in Appendix C. Table 3.2 summarizes the mineralogy composition of the samples.

Table 3.1 Mineralogy Composition of Samples

Sample	Observations and Photomicrograph References
11001 **P17** **59.3-59.4m**	**Basalt** • Fine grained groundmass of: actinolite 40%, chlorite 10%, epidote 10%, 7.5% quartz, 2.5% albite, 30% micro-crystalline alteration product – probably serecite. Photomicrographs Appendix C-1 Figures 1 to 7. • Cut by veins of: epidote with chlorite (major - probably in selvedge; Figure 8), actinolite (major - probably in selvedge; Figure 9), calcite with chlorite (minor; Figure 10), quartz with actinolite (minor; Figure 11).
11002 **P17** **76.5-76.7m**	**Gabbro** • Coarse grained groundmass of: albite 50%, actinolite 48% and probably titanite 2% ($CaTiSiO_5$). Refer to photomicrographs Appendix C-2 Figures 12 to 14, Figures 16 and 17. • Cut by significant calcite and epidote veining (Appendix C Figures 15 and 18), calcite and minor quartz veining (Figure 18) and chlorite and epidote veining (Figure 19).
11003 **P21** **38.3-38.4m**	**Basalt** • Strongly veined and segregated sample. Unveined regions: chlorite 40%, epidote 35%, quartz 15%, micro-crystalline serecite 10% (Appendix C-3 Figures 21 to 26). • Strongly veined region: calcite 50%, quartz 30%, chlorite 10%, epidote 10% (Figures 27 and 28) • Other veins: chlorite (Figure 29), quartz with minor calcite (Figure 30).

11004
P21
61.2-61.3m
	Foliated Basalt
	• Segregated rock (Appendix C-4 Figures 31 and 32) dominated by:
	    o Foliated chlorite rich bands with calcite and quartz (Figures 33 and 34)
	    o Foliated calcite rich bands with more blocky albite, quartz and lesser chlorite (Figures 35 and 36)
	• Total mineralogy: chlorite 40%, calcite 20%, albite 15%, quartz 15% and titanite (8%; Figure 37) associated with opaques (2%)

11005 **P21** **80.6-80.7m**	**Basalt** • Medium grained basalt with actinolite 30%, chlorite 30%, quartz 10%, titanite 10%, albite 5% mostly altered to micro-crystalline serecite 15% (Appendix C-5 Figures 38 to 43). • Cut by epidote veins (Figures 44 to 46) and minor epidote with quartz veining (Figure 47)
11006 **S13** **29.2-29.4m**	**Rhyolite** • Fine grained rhyolite with on average: quartz 75%, actinolite 10%, boitite 10%, opaques 5% (Appendix C-6 Figures 48 and 49). • Cut by actinolite veins (visible in Figure 51). • Adjacent to actinolite veins rock is richer in actinolite and opaques with lesser quartz and

Sample	Observations and Photomicrograph References
	biotite (Figures 50 and 51). Furthest away from actinolite veins rock is richer in quartz with no actinolite (Figure 52).
11007 **S13** **45-45.1m**	**Veined/brecciated basalt** • Mafic material between veins comprises 60% of thin section and is very heterogeneous. Average composition is: micro-crystalline serecite 40%, chlorite 30%, actinolite 10%, epidote 5%, quartz 5% and albite 10%. Examples are included in Appendix C-7 Figures 54 and 55. • Veining comprises 40% of thin section. Veins are predominantly quartz (70% of veins; Figure 53) with some narrower ones being calcite (25%) and epidote (5%) together. Photomicrographs Figures 56 to 58 show both types of veins.
11008 **P41** **5.9-6m**	**Basalt** • Fine grained basalt comprising calcite 35%, chlorite 35%, micro-crystalline serecite 25% and quartz 5% (Appendix C-8 Figures 61 to 63). • Cut by calcite veins (Figures 59 to 61).
11009 **P41** **93.7-93.8m**	**Foliated Basalt** • Fine grained, foliated basalt with chlorite 50%, quartz 20%, calcite 20% and titanite 10% (Appendix C-9 Figures 67 and 68) • Calcite veins cut the foliation (Figures 64 to 66).

11010
P13
17.4-17.5m
	Variolitic Basalt
	• Two parts to slide
	  o Light green in hand sample:
	    ▪ Very fine grained dark rock with lighter coarse grained “blobs” (Appendix C-10 Figures 69 and 70). Very fine grained mass comprises microcrystalline serecite 60% with chlorite 20% and epidote 20% (Figure 71).
	    ▪ Blobs comprise albite 20%, quartz 25%, chlorite 30%, microcrystalline serecite with epidote 25% with trace opaques (Figures 72 and 73).
	  o Grey in hand sample:
	    ▪ Fine grained basalt with circular blobs approx 1mm across (Figures 74 to 77) that probably represent varioles (not vesicles). Between the varioles mineralogy is: albite 30%, actinolite 40%, microcrystalline serecite-epidote patches 20%, quartz 5%, titanite 3%, easily identifiable epidote 2%, trace opaques and trace rutile.
	    ▪ Varioles (Figures 78 and 79) are richer in mafic minerals: chlorite 40%, actinolite 30%, titanite 5% (Figure 82 small ones in centre), epidote-serecite patches 20% (Figure 80 and 81), albite 5%, and trace quartz.
	    ▪ Cut by predominantly calcite veining (>99% of vein material) with lesser calcite veins combined with quartz/trace opaques/trace rutile. Photomicrographs Figures 83 and 84.

11011 **P13** **85.3-85.4m**	**Basalt with Quartz** • Medium grained basalt with significant quartz veining. Groundmass is actinolite 55%, microcrystalline serecite 40%, titanite 2%, epidote 2%, quartz 1%, trace opaques (Appendix C-11 Figures 89 to 94). • Veining is predominantly quartz (Figure 85) with minor calcite veins cutting quartz veining. Calcite vein is rimmed by opaques and rutile (red in hand sample) as in Figures 86 to 88).

Table 3.2 Mineralogy Composition of Samples

Sample #	Rock Type	Mineralogy Composition, % by volume									
		Actinolite	Chlorite	Epidote	Quartz	Albite	Sericite	Titanite	Calcite	Opaques	Biotite
11001	Basalt	40%	10%	10%	7.50%	2.50%	30%				
11002	Gabbro	48%				50%		2%			
11003	Pillow Basalt		40%	35%	15%		10%				
11004	Foliated Basalt		40%		15%	15%		8%	20%	2%	
11005	Basalt	30%	30%		10%	5%	15%	10%			
11006	Rhyolite	10%			75%					5%	10%
11007	Brecciated Basalt	6%	18%	4%	39%	6%	24%		3%		
11008	Pillow Basalt		35%		5%		25%		35%		
11009	Basalt		50%		20%			10%	20%		
11010	Pillow Basalt	40%		2%	5%	30%	20%	3%			
11011	Basalt	55%		2%	1%		40%	2%		trace	

Source File: BedrockThermalConductivity.1CS019.018.rev01.KYK_ksk.xlsx

4 Estimates of Thermal Properties

4.1 Thermal Conductivity

Thermal conductivities for each mineral were obtained from Clauser and Huenges (1995) and are listed in Table 4.1 as the „best estimate". For some minerals, a range of conductivities was reported depending on the method and orientation of the testing with respect to the mineral"s structural axis. The conductivity ranges are noted in the table as the minimum and maximum thermal conductivity values.

Table 4.1 Mineral Thermal Conductivities

Mineral	Best Estimate (kJ m-1 day-1 ^{0}C-1)	Minimum (kJ m-1 day-1 ^{0}C-1)	Maximum (kJ m-1 day-1 ^{0}C-1)
Actinolite	301		
Albite (plag)	185	173	202
Biotite	175	45	271
Calcite	310	178	432
Chlorite	445	264	454
Epidote	245	216	268
Opaques	-	-	-
Quartz	664	570	1123
Sericite	445		
Titanite	202		

Source File: BedrockThermalConductivity.1CS019.018.rev01.KYK_ksk.xlsx

The thermal conductivity of each sample was estimated as the weighted geometric mean of the mineral thermal conductivities and is calculated as:

$$\bar{x} = \exp\left(\frac{\sum_{i=1}^{n} w_i \ln x_i}{\sum_{i=1}^{n} w_i}\right)$$

where x_i is the thermal conductivity of mineral i obtained from Table 4.1, and w_i is the percent weight of the mineral i in the sample obtained from Table 3.1. Table 4.2 presents the estimated thermal conductivities of the samples. In the low and high range estimates, for minerals with no range of values reported in Table 4.1, the best estimate value was used.

Table 4.2 Estimated Bedrock Thermal Conductivity

#	Drillhole	Depth Interval (m)		Description	Best Estimate Thermal Conductivity (kJ m^{-1} day^{-1} °C^{-1})	Low Range Thermal Conductivity (kJ m^{-1} day^{-1} °C^{-1})	High Range Thermal Conductivity (kJ m^{-1} day^{-1} °C^{-1})
		From	To				
11001	P17	59.3	59.4	Basalt	361	317	377
11002	P17	76.5	76.7	Gabbro	234	226	245
11003	P21	38.3	38.4	Pillow Basalt	383	263	422
11004	P21	61.2	31.3	Foliated Basalt/Gabbro	350	222	405
11005	P21	80.6	80.7	Basalt	364	285	382
11006	S13	29.2	29.4	Rhyolite	485	225	676
11007	S13	45	45.1	Brecciated Basalt	466	297	553
11008	P41	5.9	6	Pillow Basalt	400	263	461
11009	P41	93.7	93.85	Basalt	415	242	483
11010	P13	17.4	17.5	Pillow Basalt	289	270	303
11011	P13	85.3	85.4	Basalt/Gabbro	350	346	352

Source File: BedrockThermalConductivity.1CS019.018.rev01.KYK_ksk.xlsx

The gabbro generally has a lower thermal conductivity compared to the basalt samples. The rhylotite has a higher thermal conductivity than the massive and pillowed basaltic flows. The brecciated basalt also has a higher thermal conductivity compared to the basalt samples.

The thermal conductivity of the rocks in the hanging wall on the west side of the Chamber is higher than in the foot wall east of the Chamber. The stronger epidote and chlorite alteration of the hanging wall that can be seen in the graphs provided in the borehole logs of Appendix A is a possible influence.

4.2 Heat Capacity

Heat capacities for each mineral at 20°C were obtained from Waples and Waples (2004) and are listed in Table 4.3. Heat capacity is a function of temperature and generally increases with higher temperatures. A great majority of the available heat capacity data is measured at 20°C and as a result all values and calculations were completed at this temperature.

Table 4.3 Mineral Heat Capacities at 20°C

Mineral	Density (g/cm^3)	Gravimetric Heat Capacity at 20°C (kJ kg^{-1} °C^{-1})	Volumetric Heat Capacity at 20°C (kJ kg^{-1} °C^{-1})
Actinolite	3.2	0.71	2300
Albite (plag)	2.6	0.73	1900
Biotite	3.0	0.77	2300
Calcite	2.7	0.82	2200
Chlorite	2.8	0.66	1800
Epidote	3.4	0.78	2700
Opaques	-	-	-
Quartz	2.6	0.74	2000
Sericite	2.9	0.76	2200
Titanite	3.5	0.81	2800

Source File: BedrockThermalConductivity.1CS019.018.rev01.KYK_ksk.xlsx

The heat capacity of each sample was estimated as the weighted arithmetic mean of the mineral heat capacity and is calculated as:

$$\bar{y} = \frac{\sum_{i=1}^{n} w_i \times y_i}{\sum_{i=1}^{n} w_i}$$

where y_i is the heat capacity of mineral i obtained from Table 4.3, and w_i is the percent weight of the mineral i in the sample obtained from Table 3.1. Table 4.4 presents the estimated heat capacities of the samples. The average heat capacity of the samples is 2100 kJ m^{-3} °C^{-1} with a range of +/- 10%.

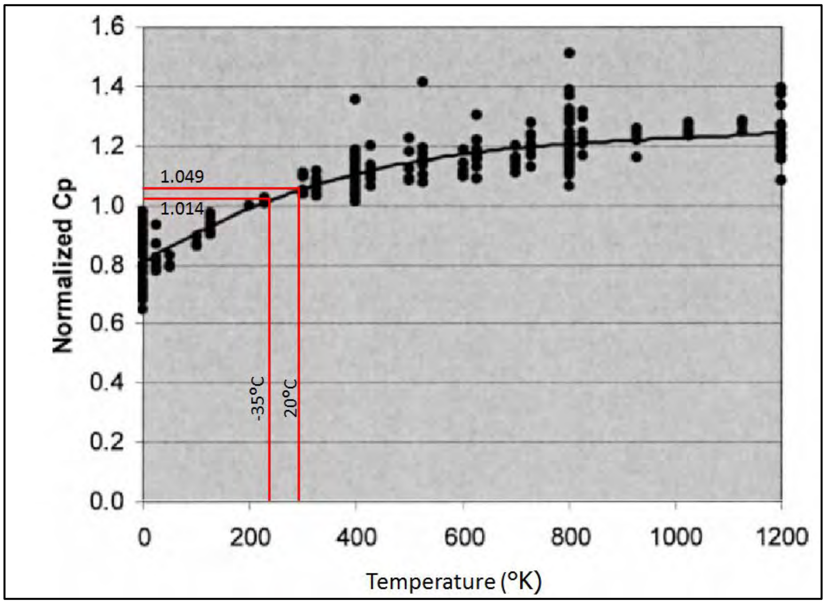
Table 4.4 Estimated Bedrock Heat Capacities at 20°C

Sample #	Drillhole	Description	Gravimetric Heat Capacity at 20°C (kJ kg^{-1} °C^{-1})	Volumetric Heat Capacity at 20°C (kJ m^{-3} °C^{-1})
11001	P17	Basalt	0.73	2200
11002	P17	Gabbro	0.72	2100
11003	P21	Pillow Basalt	0.72	2200
11004	P21	Foliated Basalt/Gabbro	0.71	2000
11005	P21	Basalt	0.72	2100
11006	S13	Rhyolite	0.70	1900
11007	S13	Brecciated Basalt	0.73	2000
11008	P41	Pillow Basalt	0.74	2100
11009	P41	Basalt	0.72	2000
11010	P13	Pillow Basalt	0.72	2100
11011	P13	Basalt/Gabbro	0.73	2300

Source File: BedrockThermalConductivity.1CS019.018.rev01.KYK_ksk.xlsx

The calculated heat capacities provided in Table 4.4 are likely higher than actual around the FOS due to differences in the bedrock temperature. The bedrock temperatures will range from approximately 1°C to 4°C at the start of the study to a low of -35°C in the frozen areas near the freeze pipes. As these temperatures are lower than the 20°C temperature used in Table 4.4 and heat capacity changes with temperature, the heat capacities require to be adjusted lower.

Figure 2 shows a plot from Waples and Waples (2004) with a best fit curve of normalized heat capacities versus temperatures used in their study. The normalization was completed by dividing the minerals‟ heat capacity over a range of temperatures by their heat capacity at 200°K. The graph shows that for temperatures between +20°C and -35°C the most probable reduction in the heat capacity is approximately 3.5%.



Source File: Figures.CoreReport.1CS019.018.pptx

Figure 2 Normalized Heat Capacity Vs. Temperature

Prepared by

Arlene Laudrum, P.Geol.

Peter Mikes, P. Eng.

Kirsty Ketchum, P.Geol.

Reviewed by

Dan Hewitt, P.Eng.

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

5 References

SRK (2010). Giant Mine Freeze Optimization Study Interim As-built Report

Clauser, C. and Huenges, E. (1995). Thermal Conductivity of Rocks and Minerals. In Rock Physics and Phase Relations: a Handbook of Physical Constants, Vol. 3 pp. 105-126.

Waples and Waples. 2004. A Review and Evaluation of Specific Heat Capacities of Rocks, Minerals, and Subsurface Fluids. Part 1: Minerals and Nonporous Rocks

Appendices

Appendix A: Borehole Logs

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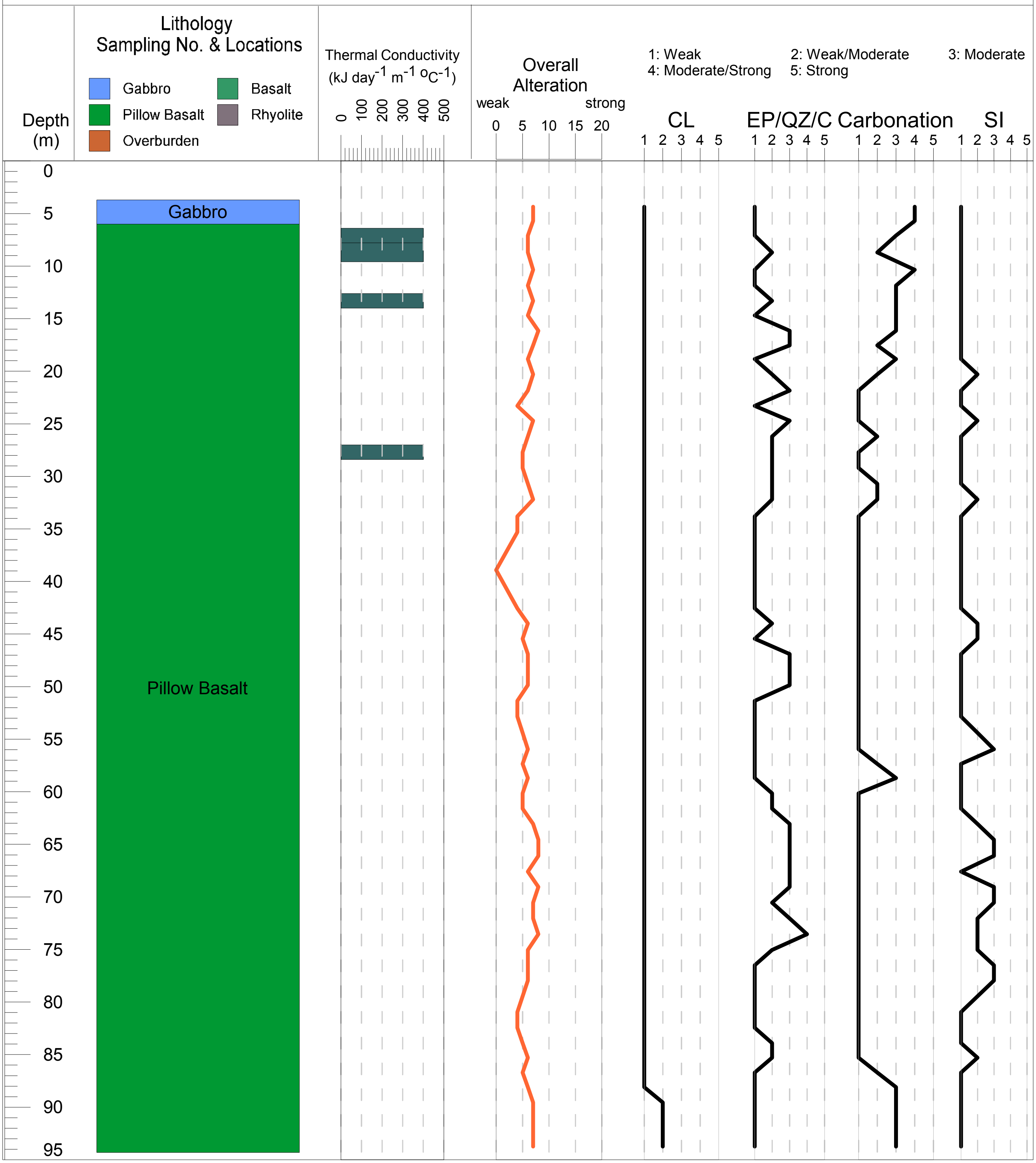
HOLE ID:	**P01**
LOCATION:	Yellowknife, NWT
PROJECT NO:	1CS019.018.0001
PROJECT:	Giant
CLIENT:	Public Works and Government Services Canada

COORDINATES:	E 635916.52 N 6932607.61
DATUM:	NAD 83 UTM Zone 11
GROUND ELEV (m):	166.24
AZIMUTH:	0
DIP:	90 deg
EOH (m):	71.94
TOTAL DEPTH (m):	94.3



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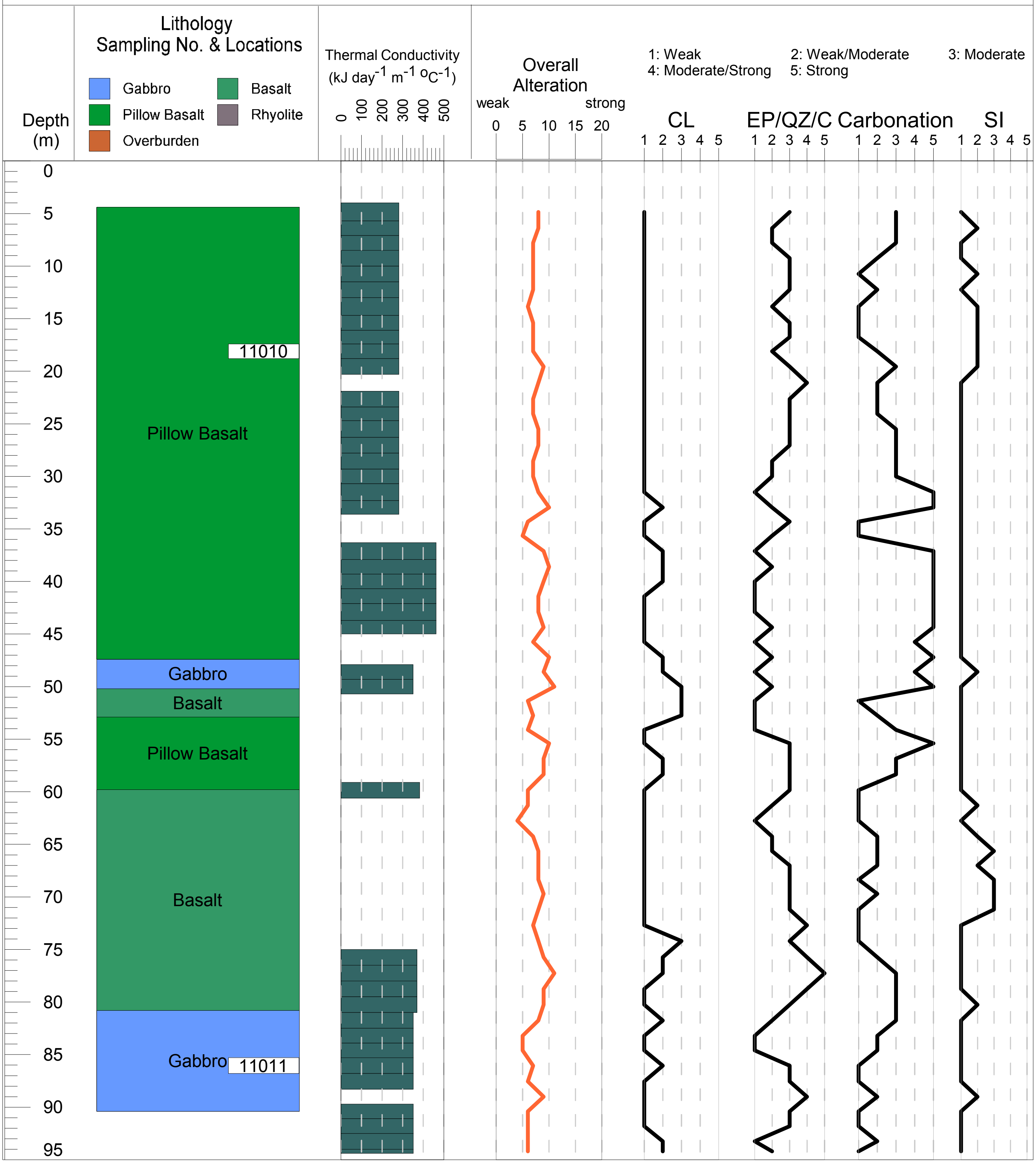
HOLE ID:	**P13**	COORDINATES:	E 635891.02 N 6932581.68
LOCATION:	Yellowknife, NWT	DATUM:	NAD 83 UTM Zone 11
PROJECT NO:	1CS019.018.0001	GROUND ELEV (m):	166.5
		AZIMUTH:	0
		DIP:	90 deg
		EOH (m):	73.5
		TOTAL DEPTH (m):	93

PROJECT: Giant

CLIENT: Public Works and Government Services Canada



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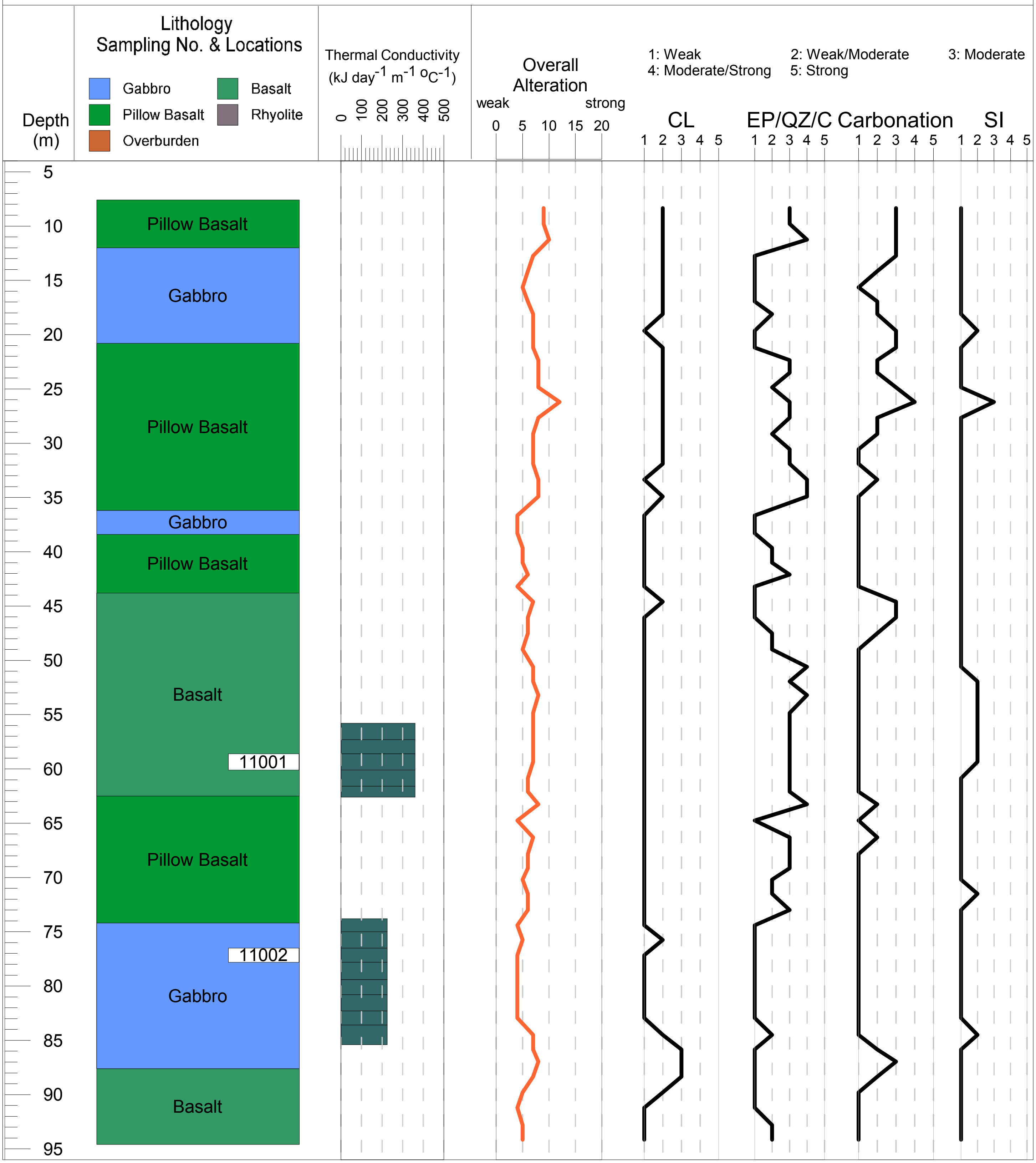
HOLE ID: **P17**
LOCATION: Yellowknife, NWT
PROJECT NO: 1CS019.018.0001

COORDINATES: E635886.93 N6932596.82
DATUM: NAD 83 UTM Zone 11
GROUND ELEV (m): 166.06
AZIMUTH: 0
DIP: 90 deg
EOH (m): 70.46
TOTAL DEPTH (m): 95.6

PROJECT: Giant
CLIENT: Public Works and Government Services Canada



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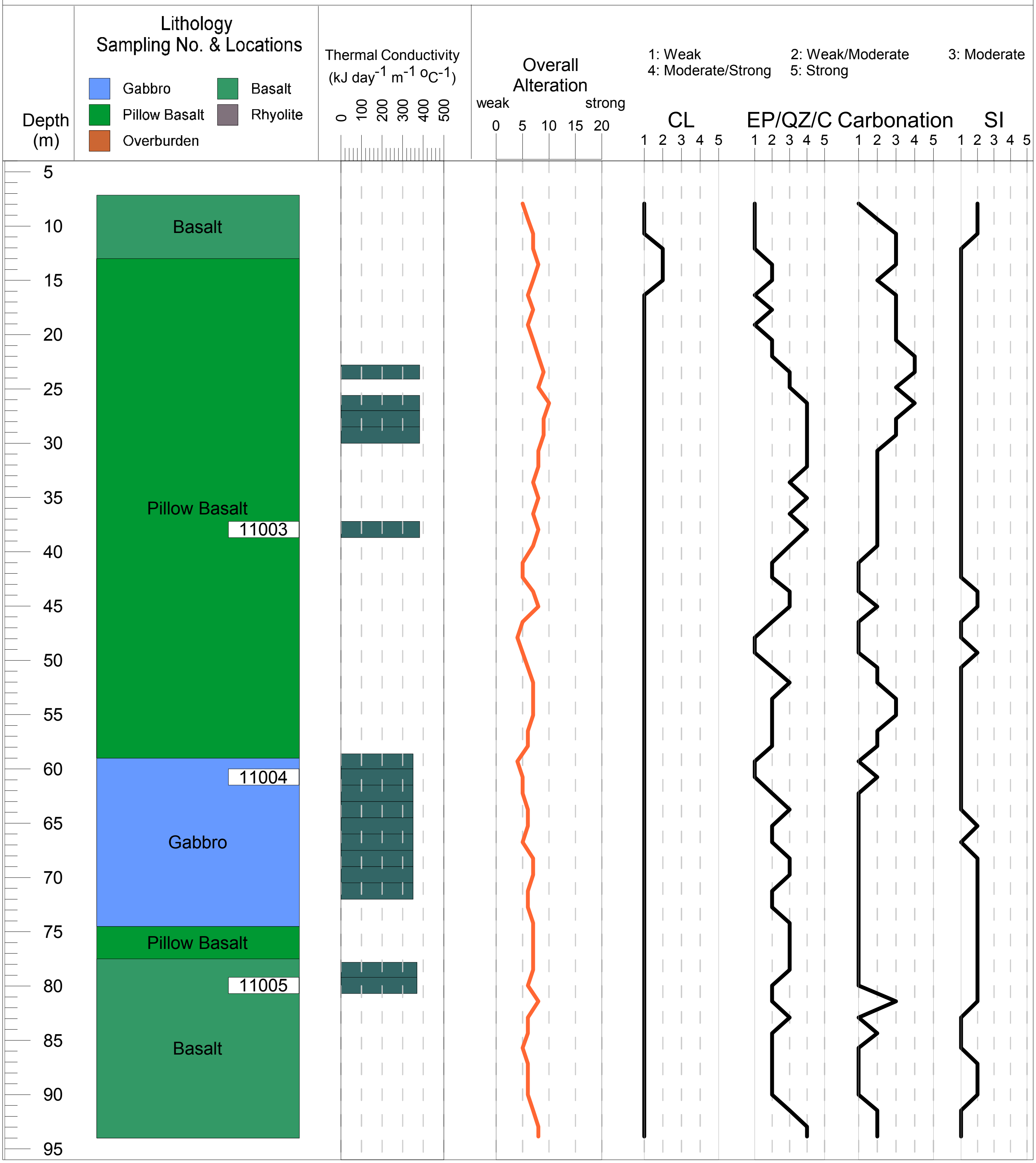
HOLE ID: **P21**
LOCATION: Yellowknife, NWT
PROJECT NO: 1CS019.018.0001

COORDINATES: E 635890.57 N 6932612.49
DATUM: NAD 83 UTM Zone 11
GROUND ELEV (m): 166.15
AZIMUTH: 0
DIP: 90 deg
EOH (m): 71.95
TOTAL DEPTH (m): 94.2

PROJECT: Giant
CLIENT: Public Works and Government Services Canada



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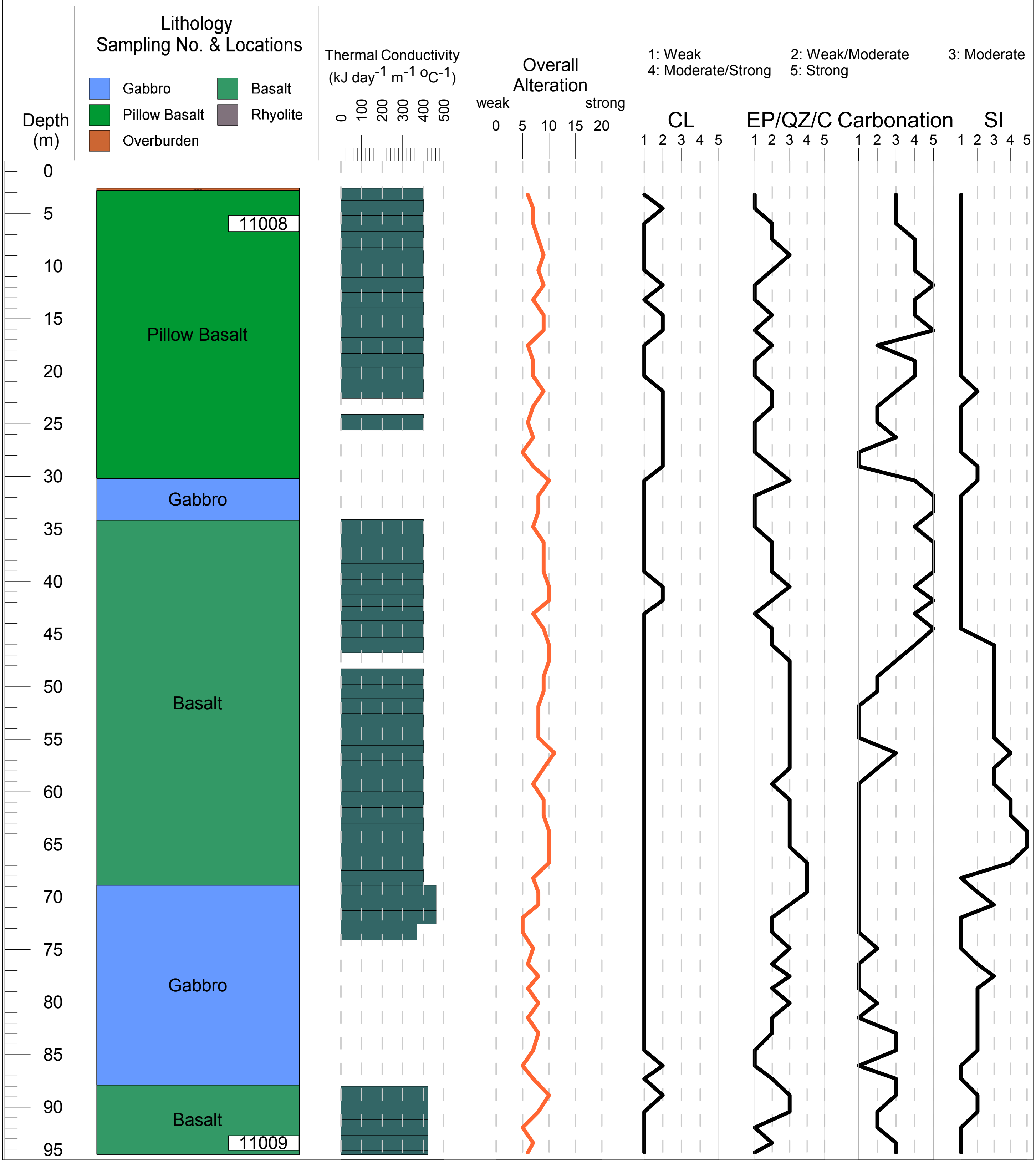
Public Works and Government Services Canada

HOLE ID: **P41**
LOCATION: Yellowknife, NWT
PROJECT NO: 1CS019.018.0001

COORDINATES: E 635909.6 N 6932592.66
DATUM: NAD 83 UTM Zone 11
GROUND ELEV (m): 166.5
AZIMUTH: 0
DIP: 90 deg
EOH (m): 72
TOTAL DEPTH (m): 94.5

PROJECT: Giant
CLIENT: Public Works and Government Services Canada



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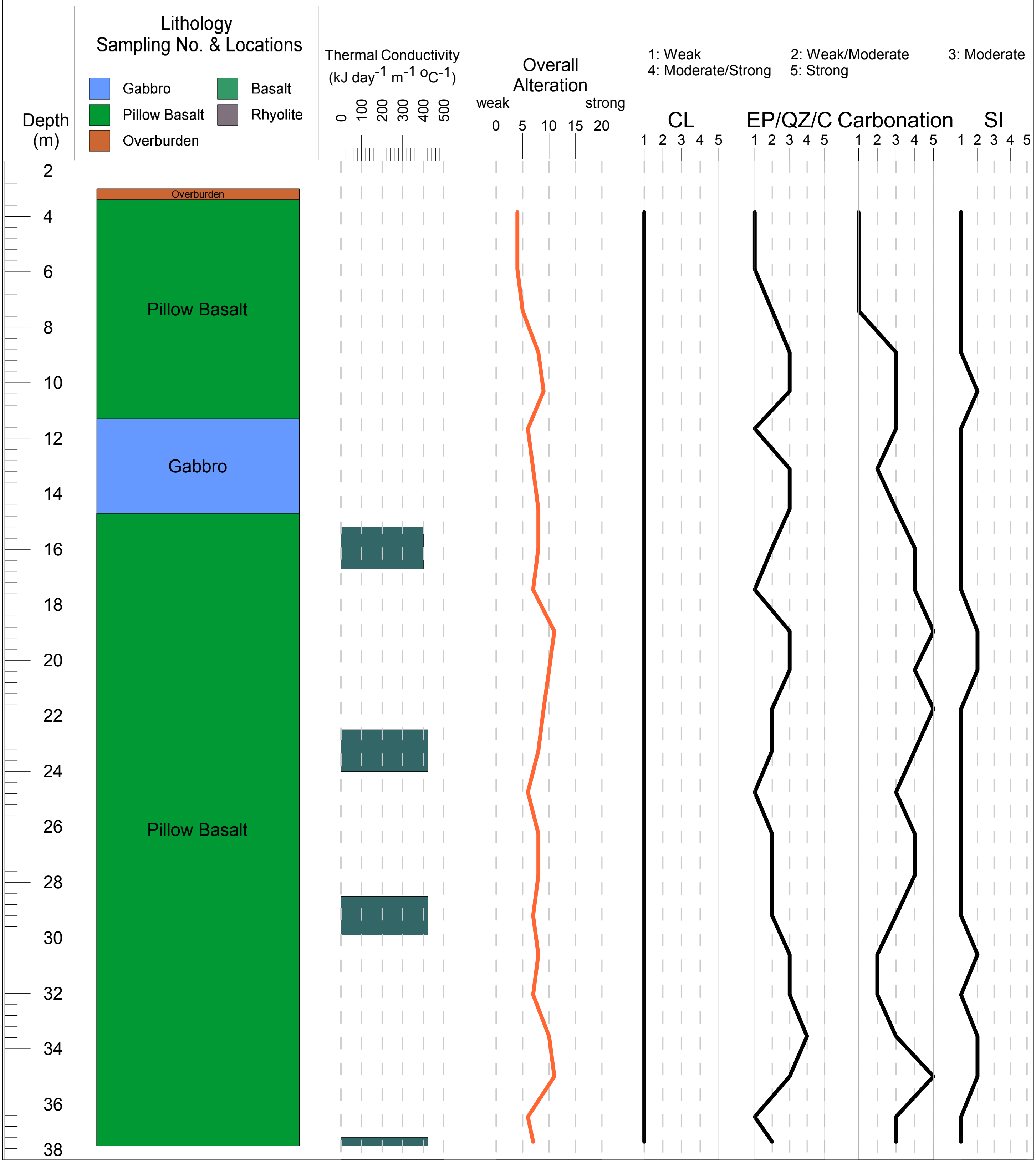
HOLE ID:	**S04**	COORDINATES:	E635905.1 N6932601.9
LOCATION:	Yellowknife, NWT	DATUM:	NAD 83 UTM Zone 11
PROJECT NO:	1CS019.018.0001	GROUND ELEV (m):	166.3
		AZIMUTH:	0
		DIP:	90 deg
PROJECT:	Giant	EOH (m):	129.3
CLIENT:	Public Works and Government Services Canada	TOTAL DEPTH (m):	37



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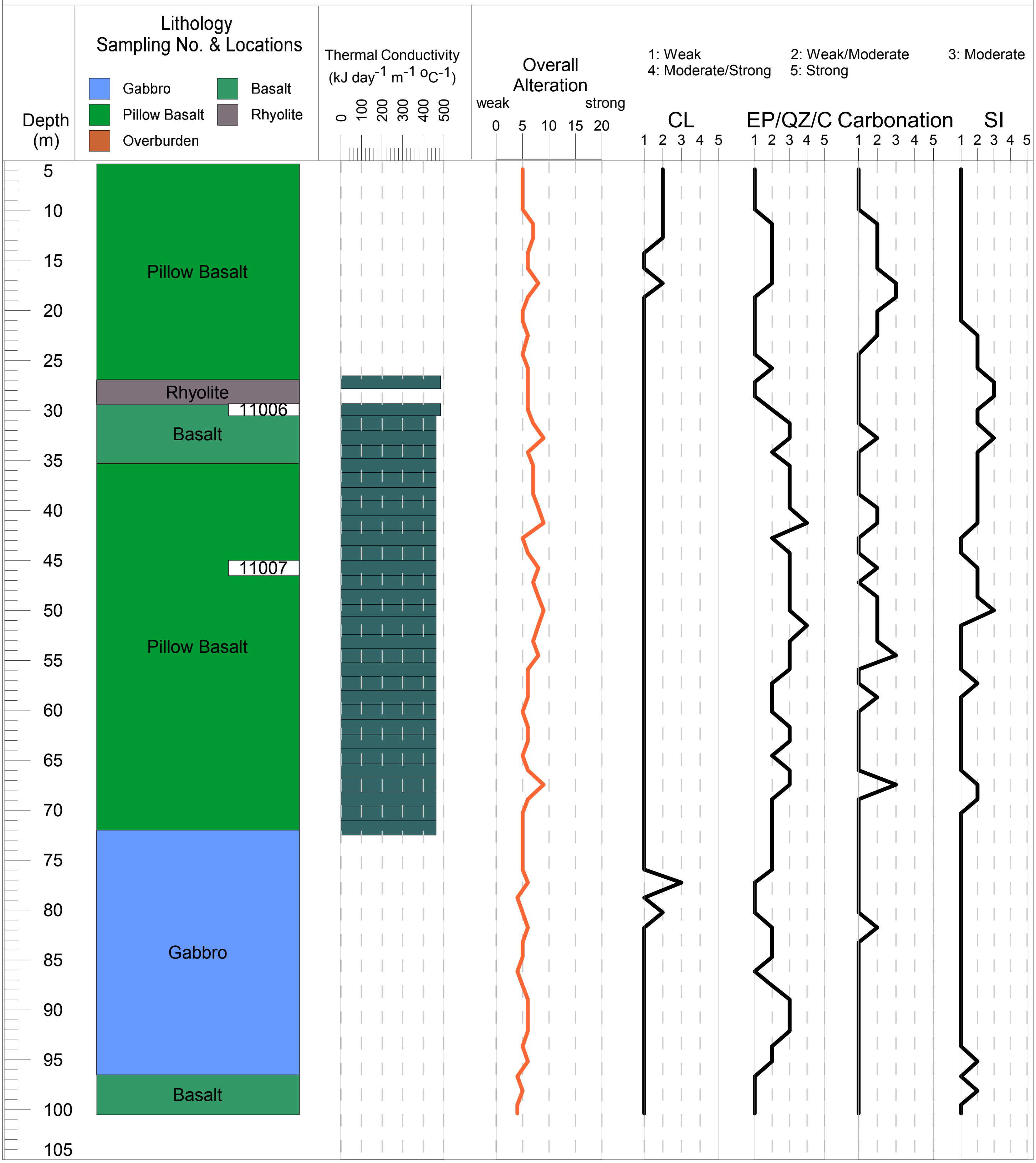
HOLE ID:	**S13**	COORDINATES:	E 635893 N 6932605.5
LOCATION:	Yellowknife, NWT	DATUM:	NAD 83 UTM Zone 11
PROJECT NO:	1CS019.018.0001	GROUND ELEV (m):	166.1
		AZIMUTH:	0
		DIP:	90 deg
		EOH (m):	65.6
		TOTAL DEPTH (m):	100.5

PROJECT: Giant

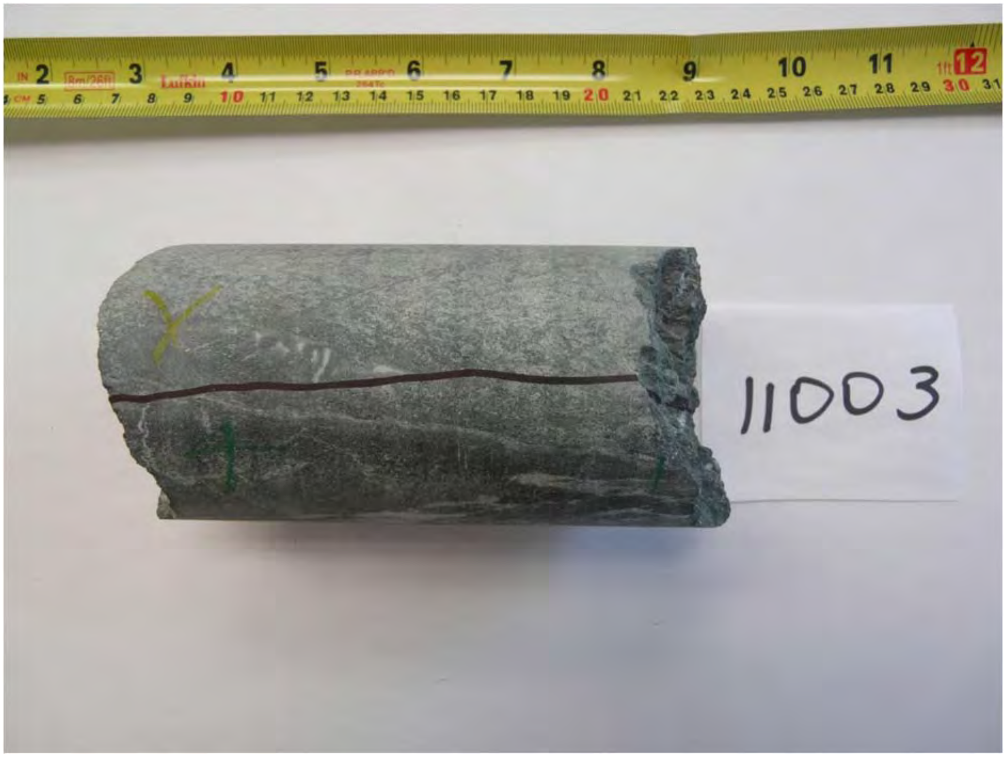
CLIENT: Public Works and Government Services Canada



Appendix B: Drill Core Photographs

Sample: 11002

Sample: 11001



Sample: 11003

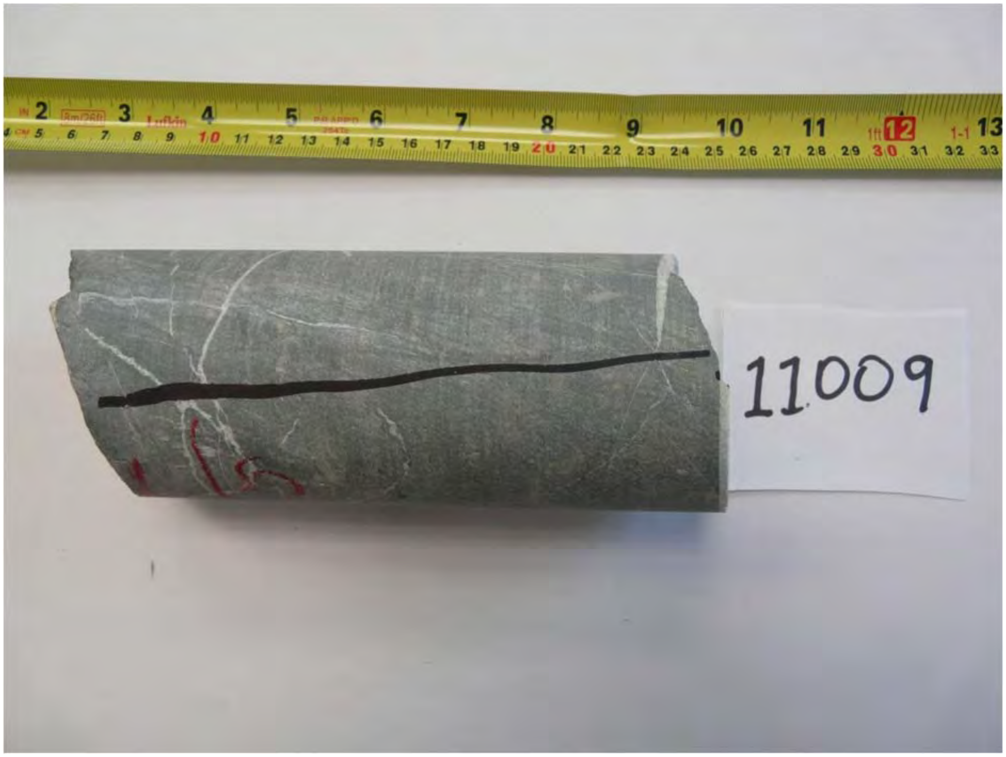
Sample: 11004

Sample: 11005

Sample: 11006

Sample: 11007

Sample: 11008



Sample: 11009

Sample: 11010

Sample: 11011

Appendix C: Thin Section Photographs

Appendix C-1: Sample 11001

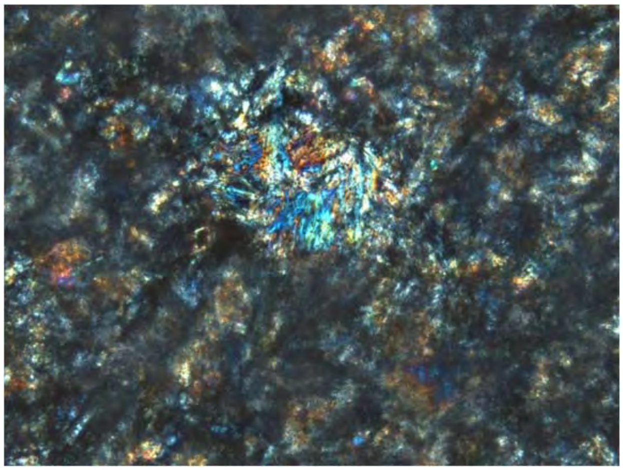


Figure 1: Sample 11001 under Cross Polarized Light. 0.75mm.

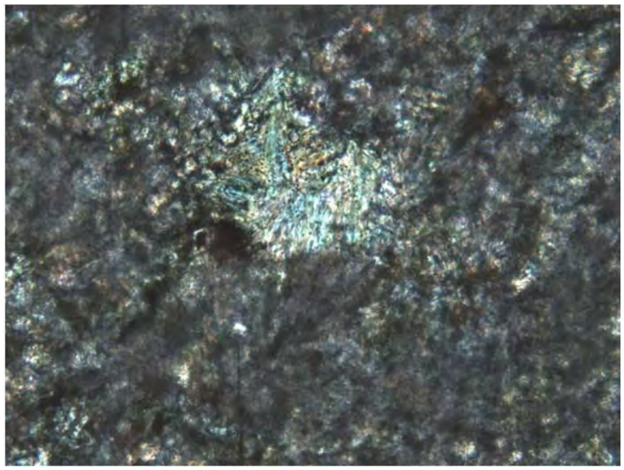


Figure 2: Sample 11001 under Plane Polarized Light. 0.75mm

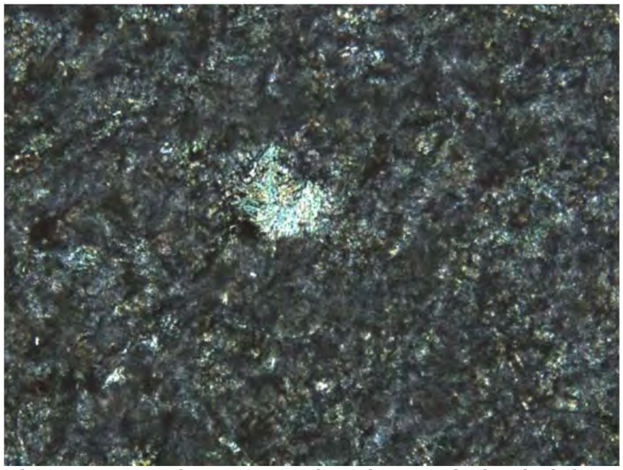


Figure 3: Sample 11001 under Plane Polarized Light. 1.1mm

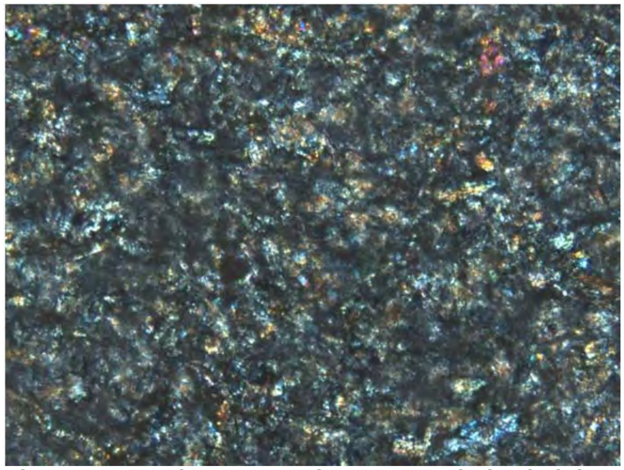


Figure 4: Sample 11001 under Cross Polarized Light. 1.1mm

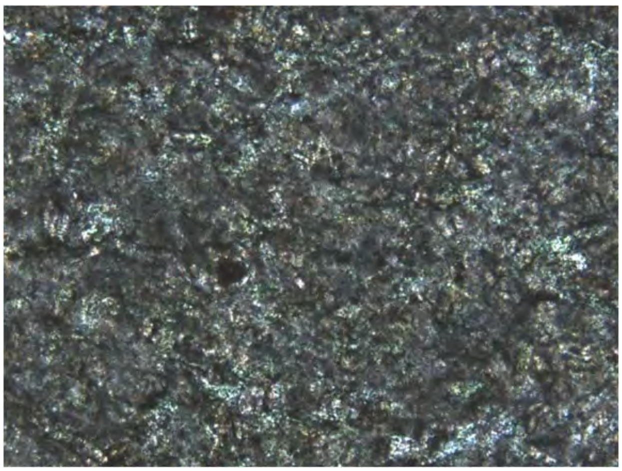


Figure 5: Sample 11001 under Plane Polarized Light. 1.1mm

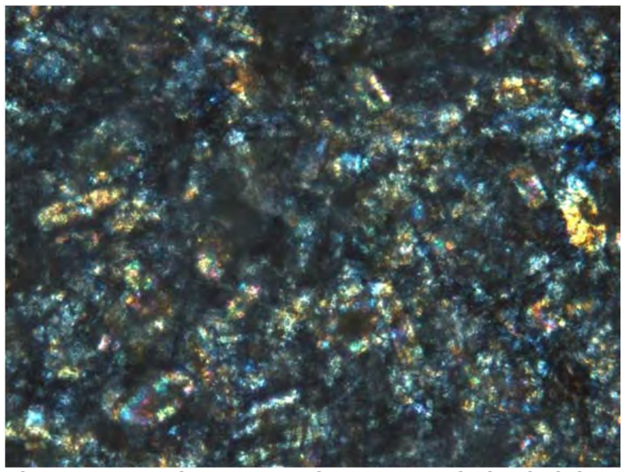


Figure 6: Sample 11001 under Cross Polarized Light. 0.75mm

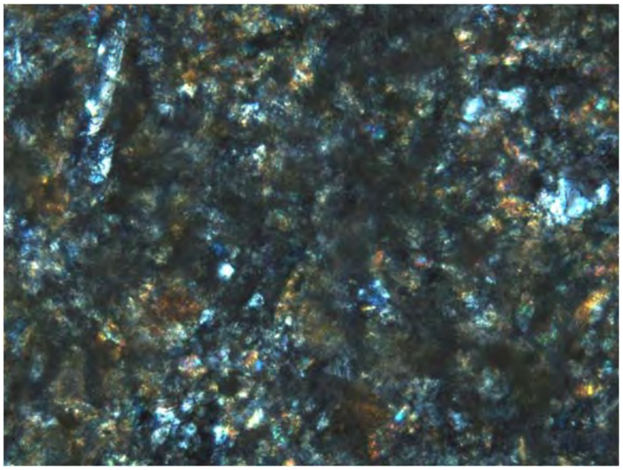


Figure 7: Sample 11001 under Cross Polarized Light. 0.75mm

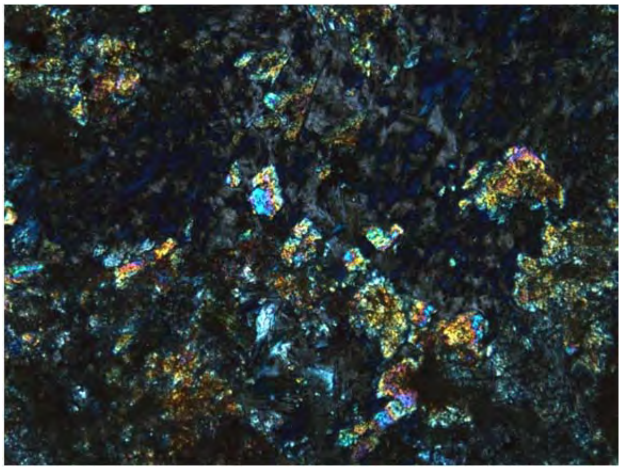


Figure 8: Sample 11001 under Cross Polarized Light. 1.1mm

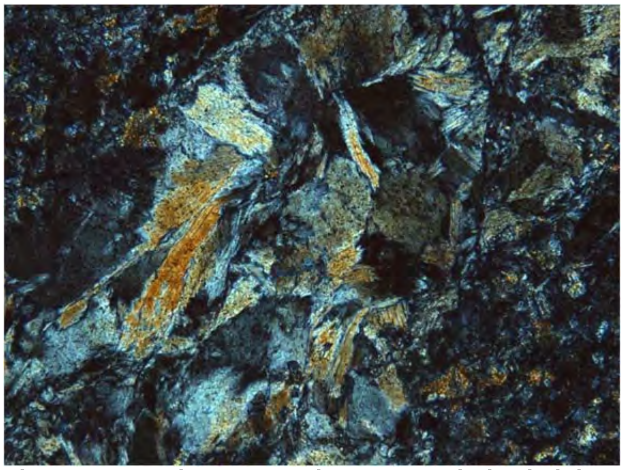


Figure 9: Sample 11001 under Cross Polarized Light. 1.1mm

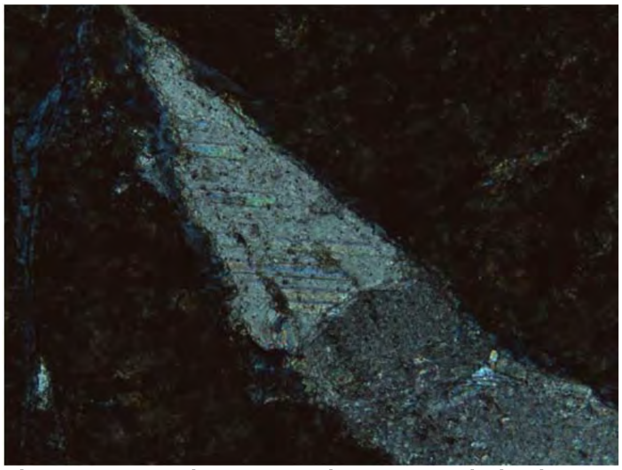


Figure 10: Sample 11001 under Cross Polarized Light. 1.1mm

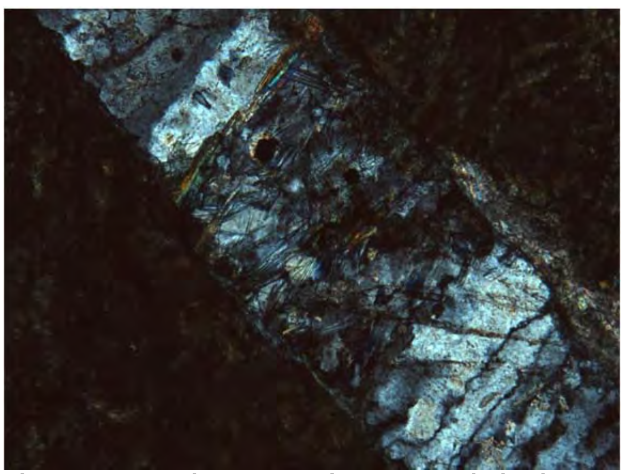


Figure 11: Sample 11001 under Cross Polarized Light. 1.1mm

Appendix C-2: Sample 11002

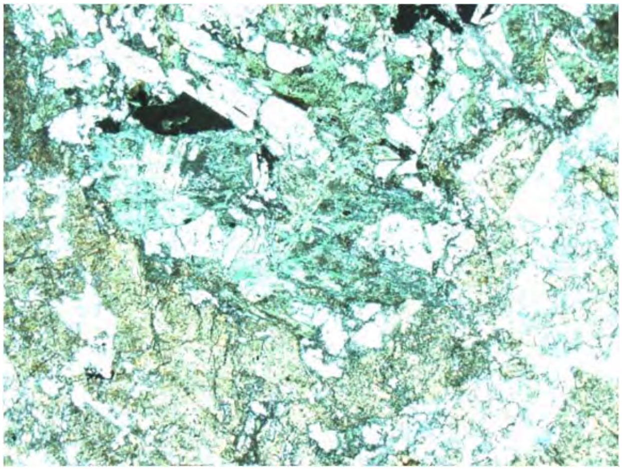


Figure 12: Sample 11002 under Plane Polarized Light. 4.5mm

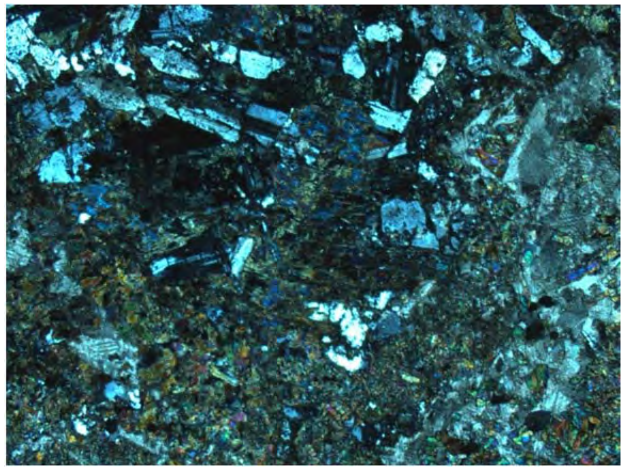


Figure 13: Sample 11002 under Cross Polarized Light. 4.5mm

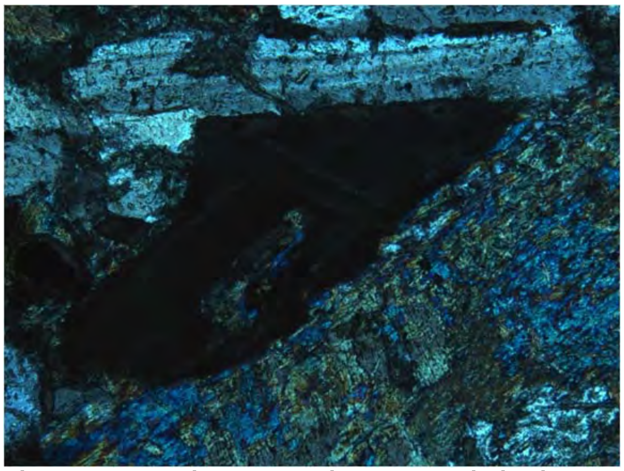


Figure 14: Sample 11002 under Cross Polarized Light. 1.1mm

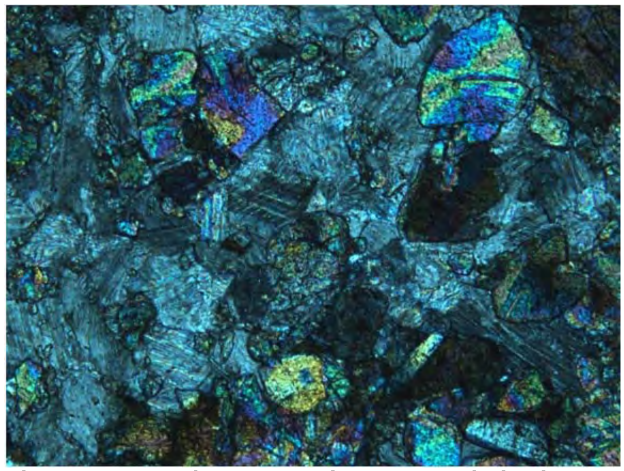


Figure 15: Sample 11002 under Cross Polarized Light. 1.1mm

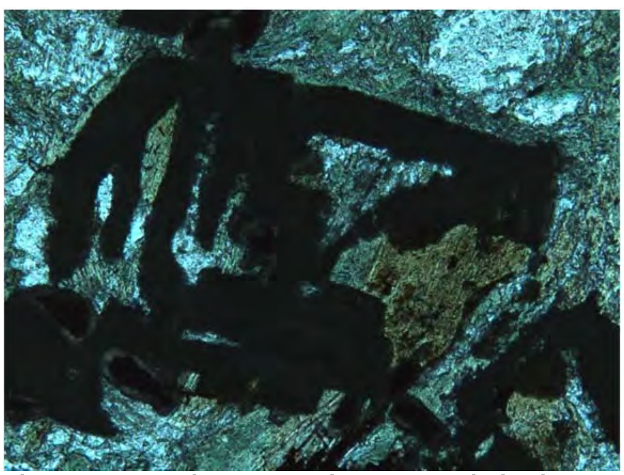


Figure 16: Sample 11002 under Cross Polarized Light. 1.1mm

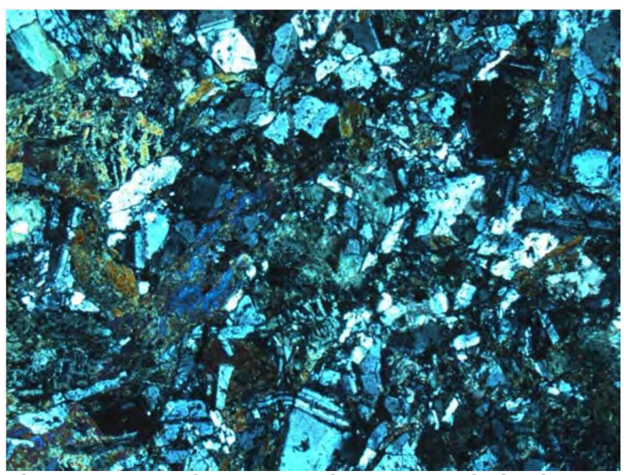


Figure 17: Sample 11002 under Cross Polarized Light. 4.5mm

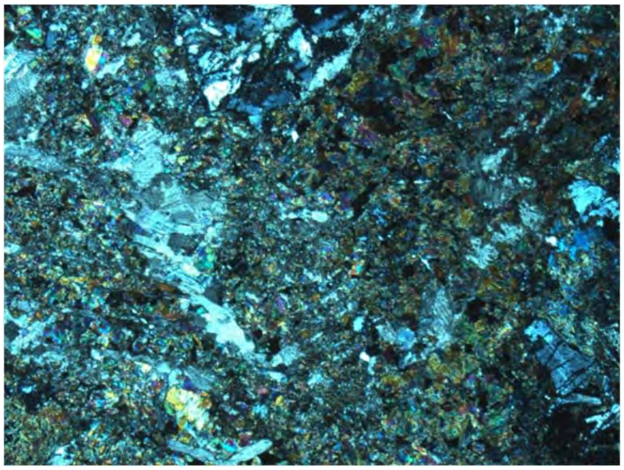


Figure 18: Sample 11002 under Cross Polarized Light. 4.5mm

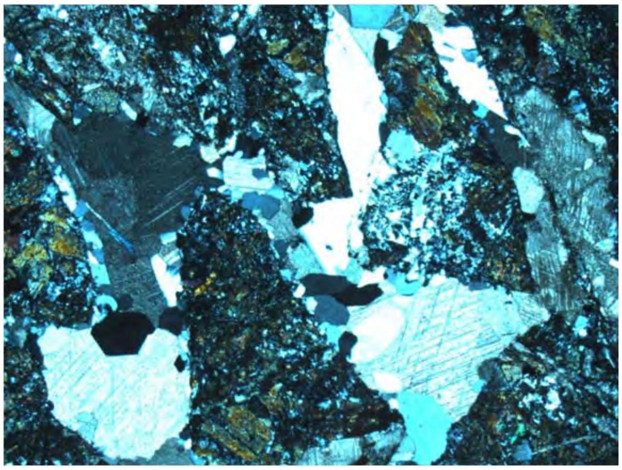


Figure 19: Sample 11002 under Cross Polarized Light. 4.5mm

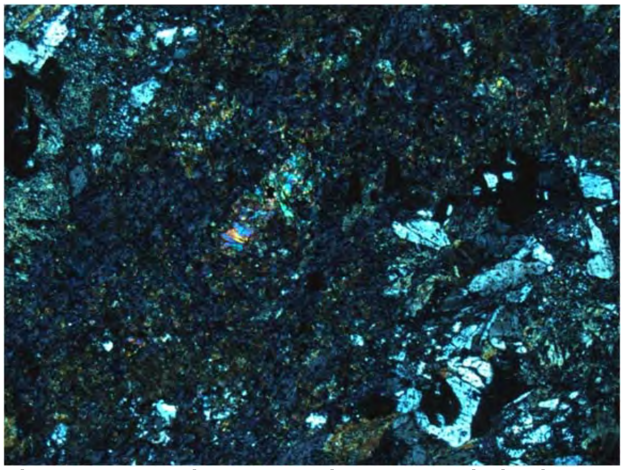


Figure 20: Sample 11002 under Cross Polarized Light. 4.5mm

Appendix C-3: Sample 11003

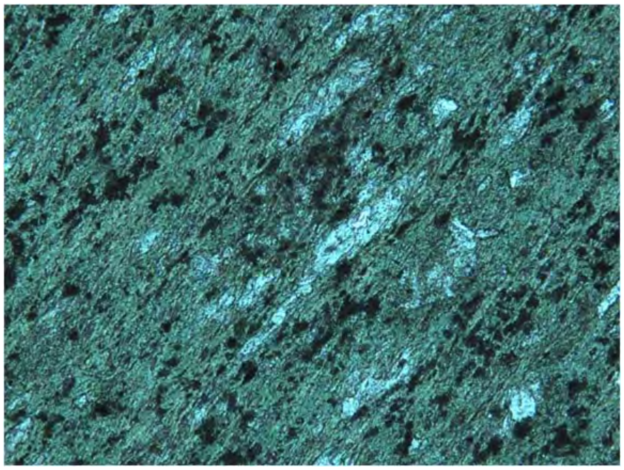


Figure 21: Sample 11003 under Plane Polarized Light. 1.1mm

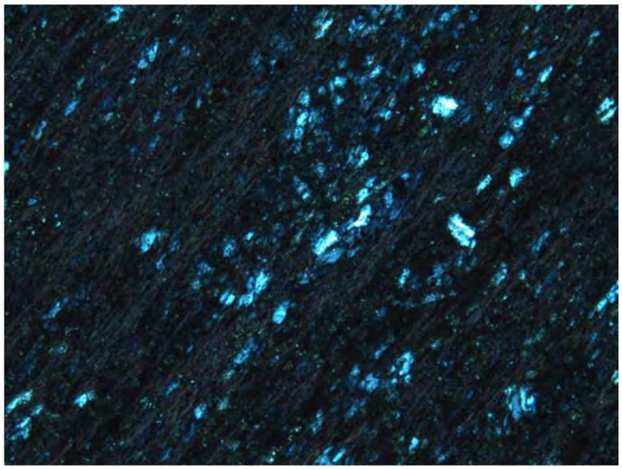


Figure 22: Sample 11003 under Cross Polarized Light. 1.1mm

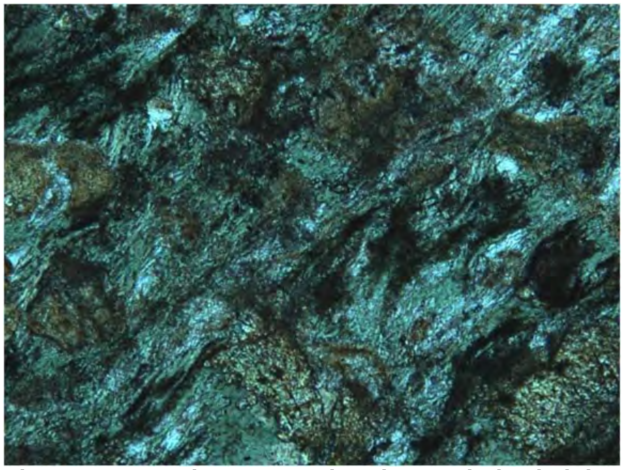


Figure 23: Sample 11003 under Plane Polarized Light. 1.1mm

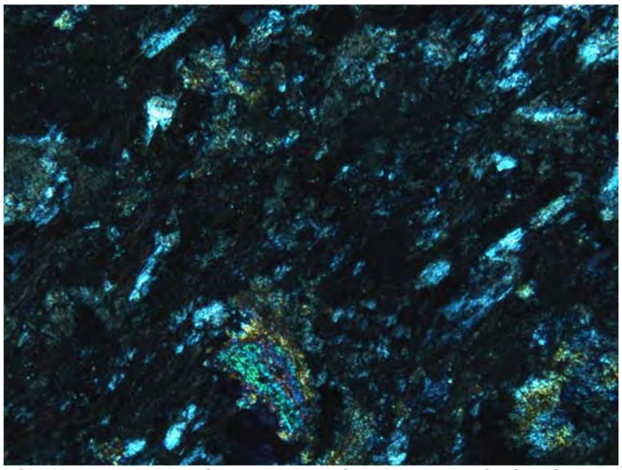


Figure 24: : Sample 11003 under Cross Polarized Light. 1.1mm

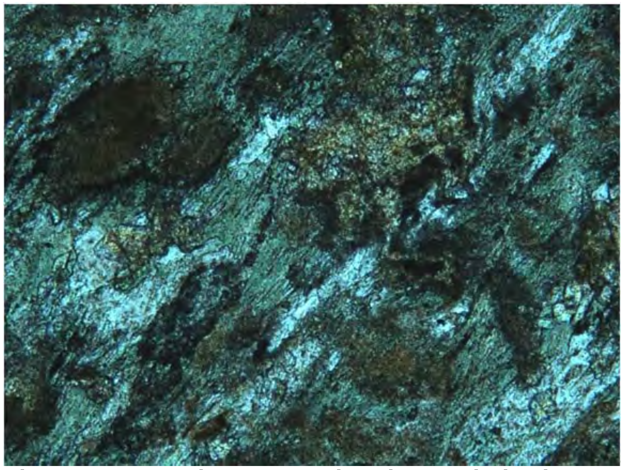


Figure 25 : Sample 11003 under Plane Polarized Light. 1.1mm

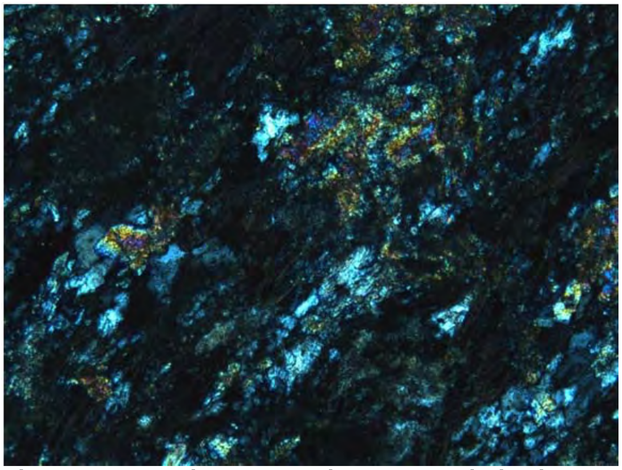


Figure 26: Sample 11003 under Cross Polarized Light. 1.1mm

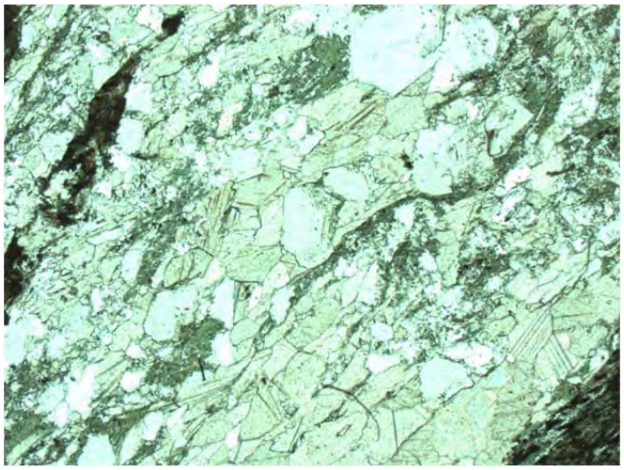


Figure 27: Sample 11003 under Plane Polarized Light. 4.5mm

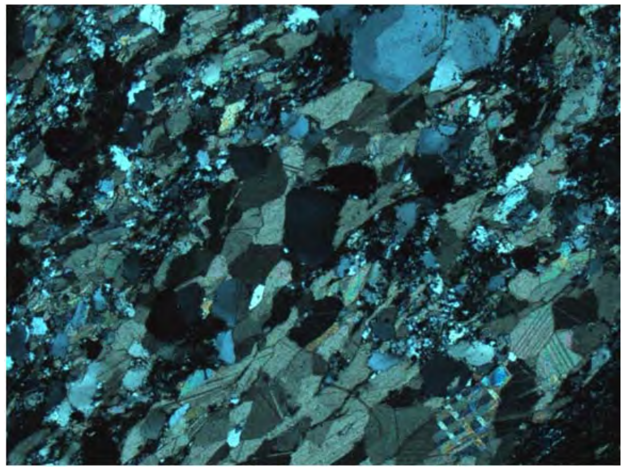


Figure 28: Sample 11003 under Cross Polarized Light. 4.5mm

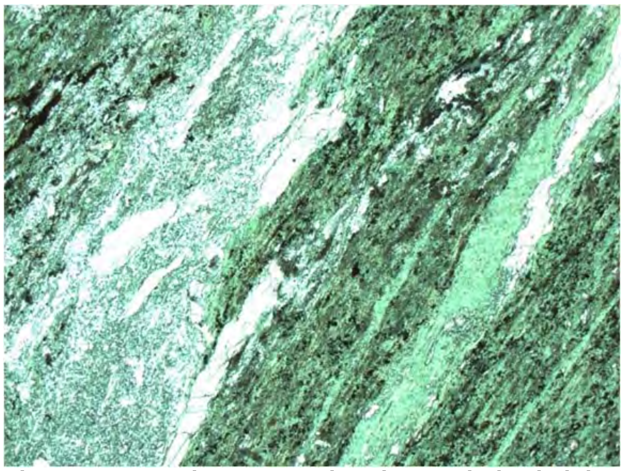


Figure 29: Sample 11003 under Plane Polarized Light. 4.5mm

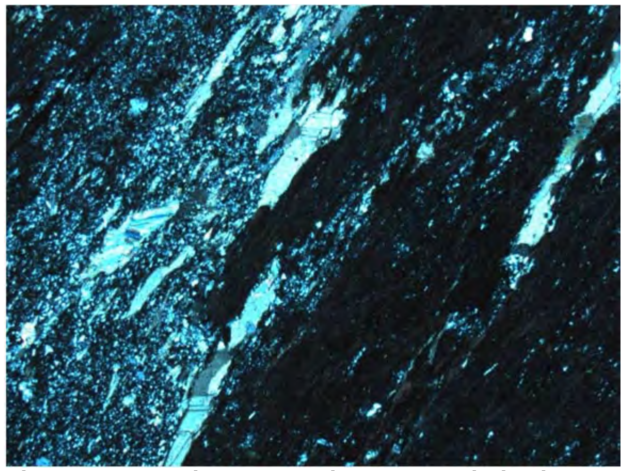


Figure 30: Sample 11003 under Cross Polarized Light. 4.5mm

Appendix C-4: Sample 11004

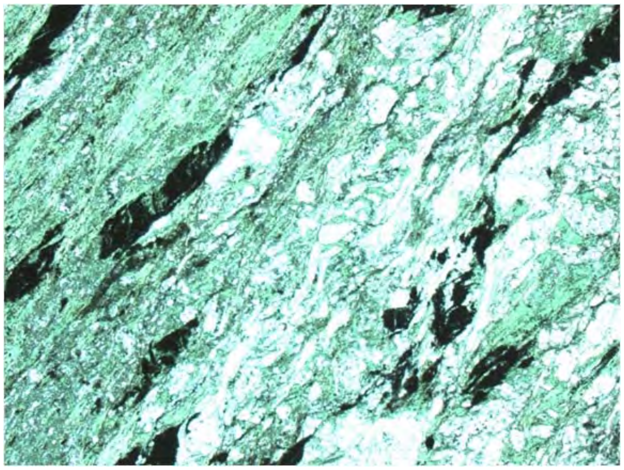


Figure 31: Sample 11004 under Plane Polarized Light. 4.5mm

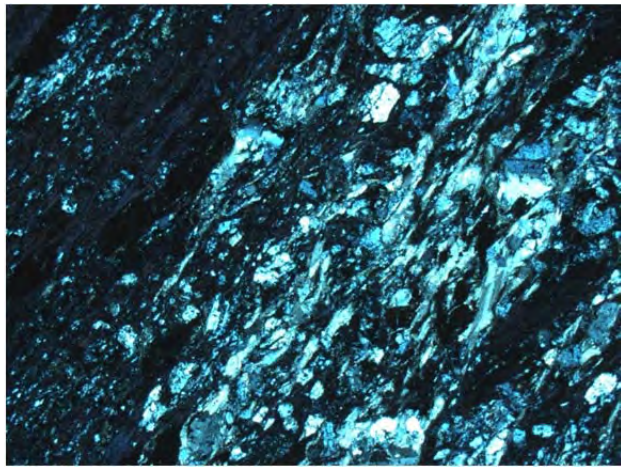


Figure 32: Sample 11004 under Cross Polarized Light. 4.5mm

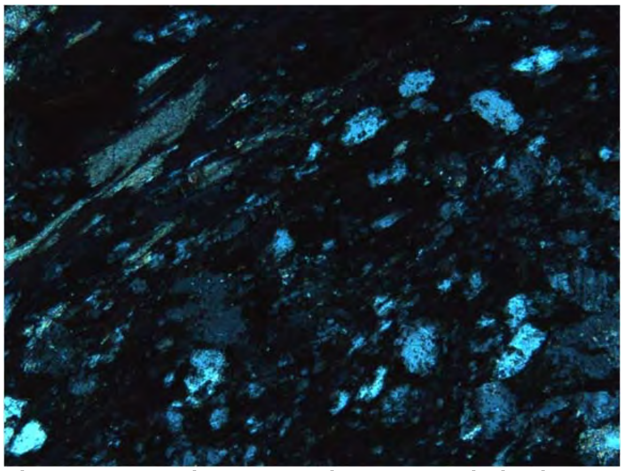


Figure 33: Sample 11004 under Cross Polarized Light. 1.1mm

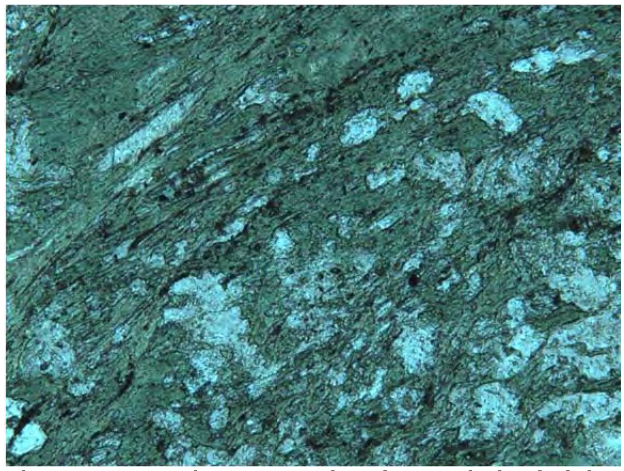


Figure 34: Sample 11004 under Plane Polarized Light. 1.1mm

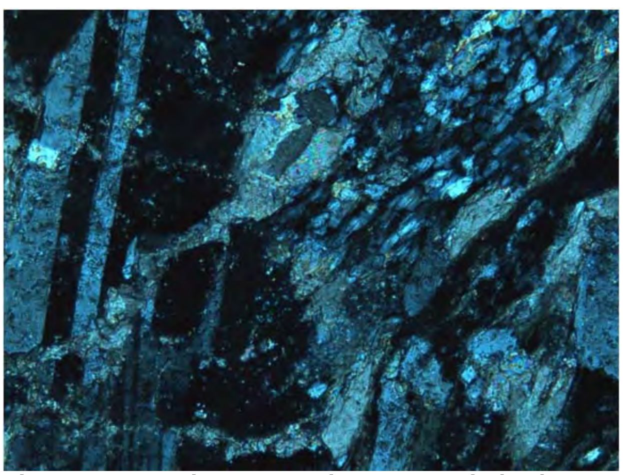


Figure 35: Sample 11004 under Cross Polarized Light. 1.1mm

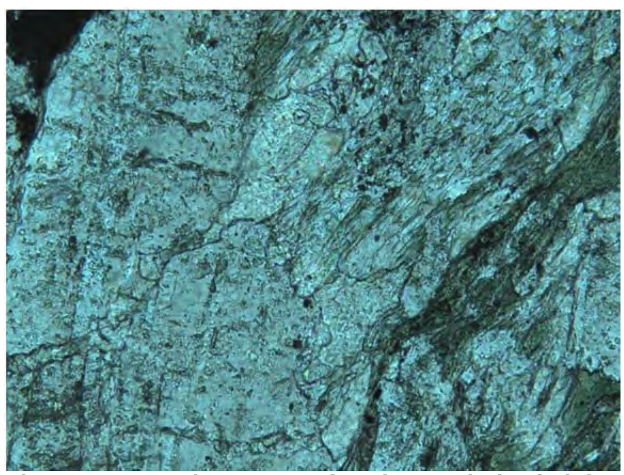


Figure 36: Sample 11004 under Plane Polarized Light. 1.1mm

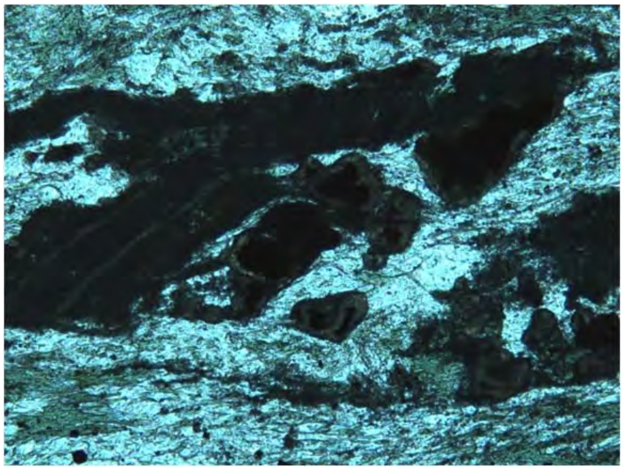


Figure 37: Sample 11004 under Plane Polarized Light. 1.1mm

Appendix C-5: Sample 11005

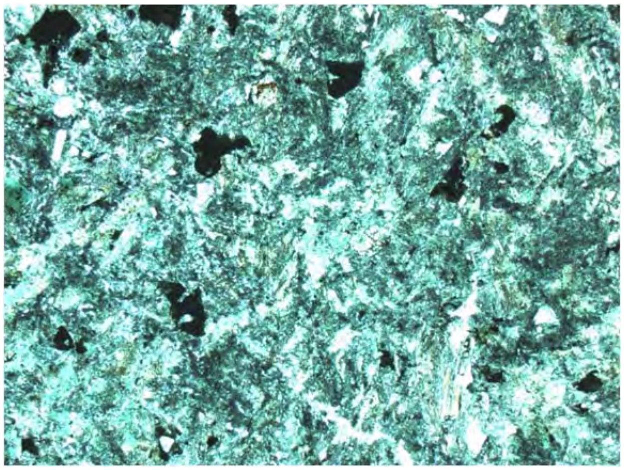


Figure 38: Sample 11005 under Plane Polarized Light. 4.5mm

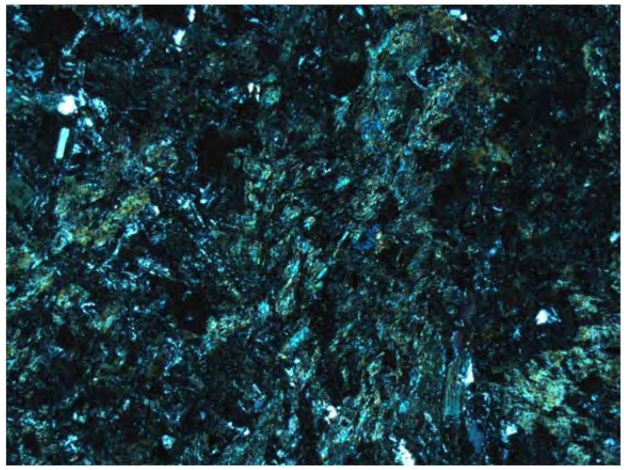


Figure 39: Sample 11005 under Cross Polarized Light. 4.5mm

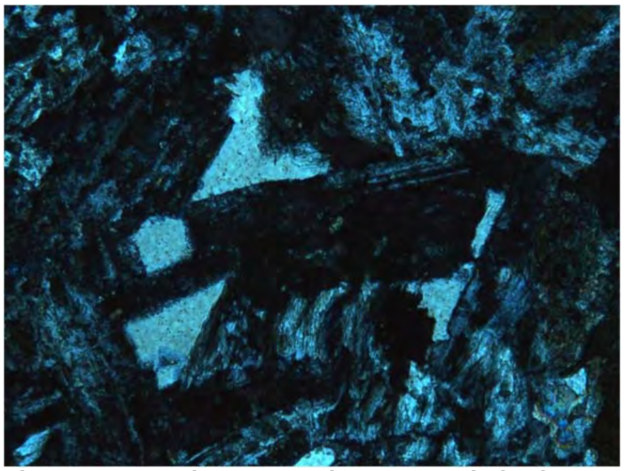


Figure 40: Sample 11005 under Cross Polarized Light. 1.1mm

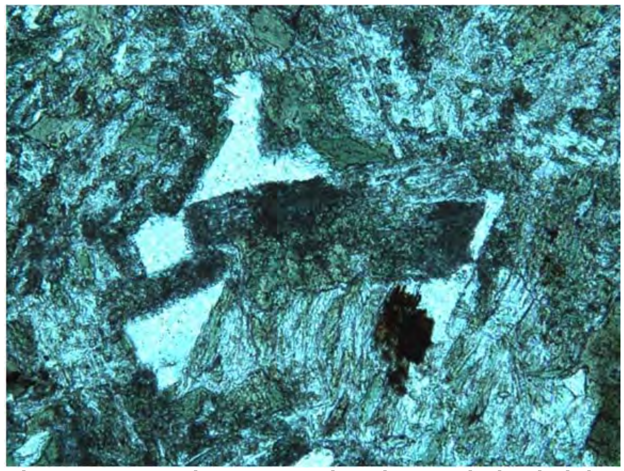


Figure 41: Sample 11005 under Plane Polarized Light. 1.1mm

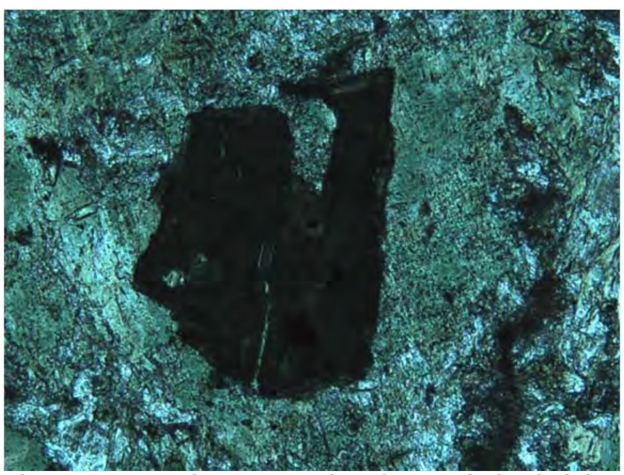


Figure 42: Sample 11005 under Plane Polarized Light. 1.1mm

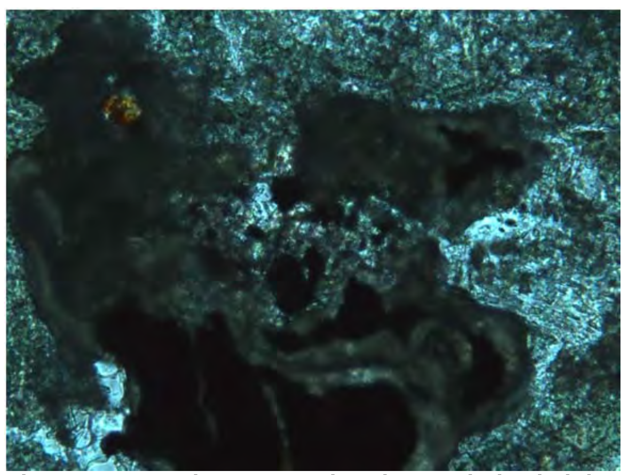


Figure 43: Sample 11005 under Plane Polarized Light. 0.75mm

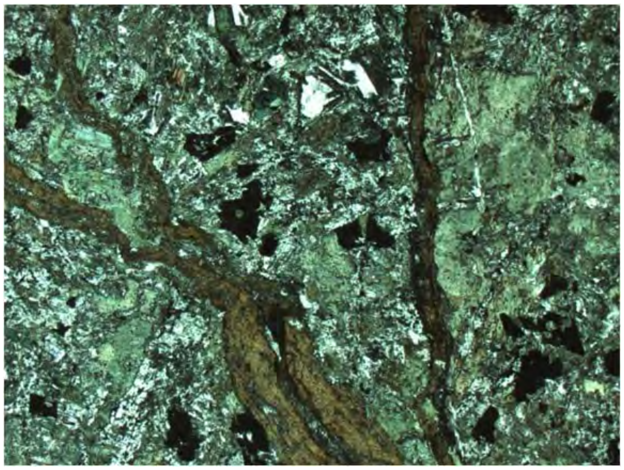


Figure 44: Sample 11005 under Plane Polarized Light. 4.5mm

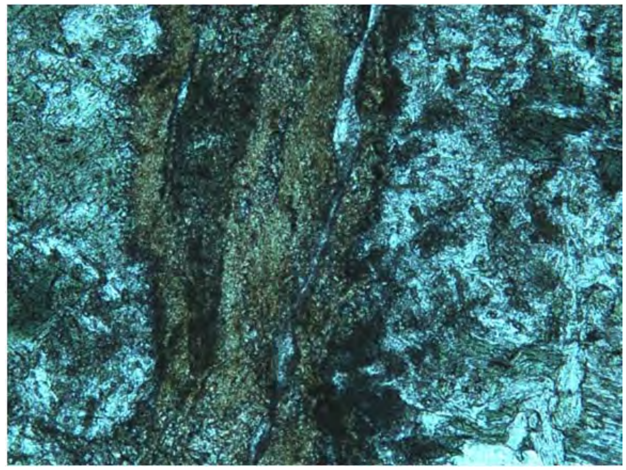


Figure 45: Sample 11005 under Plane Polarized Light. 1.1mm

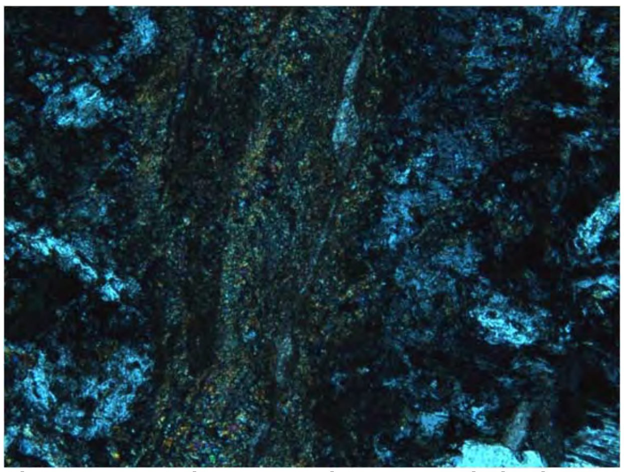


Figure 46: Sample 11005 under Cross Polarized Light. 1.1mm

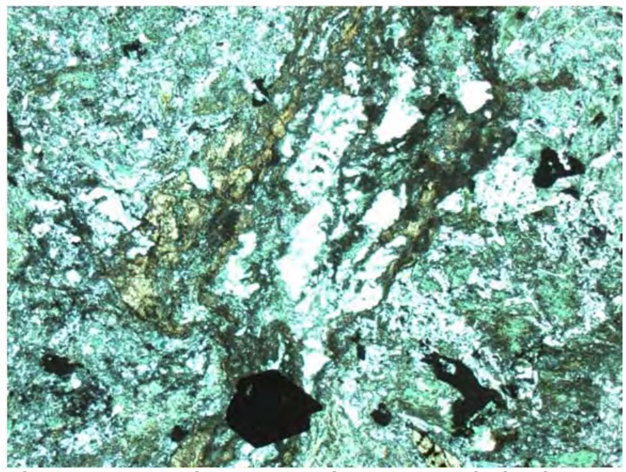


Figure 47: Sample 11005 under Cross Polarized Light. 4.5mm

Appendix C-6: Sample 11006

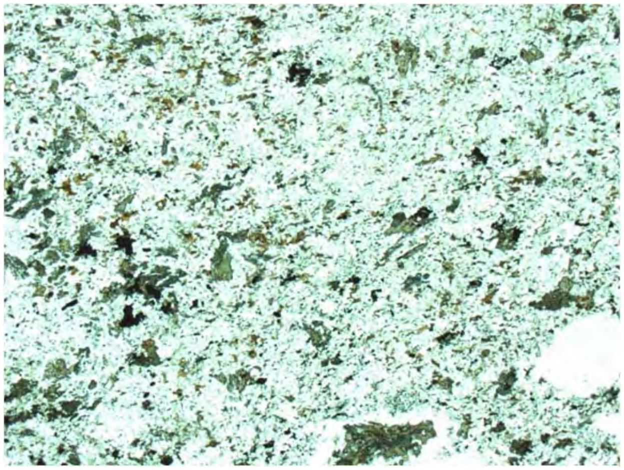


Figure 48: Sample 11006 under Plane Polarized Light. 4.5mm

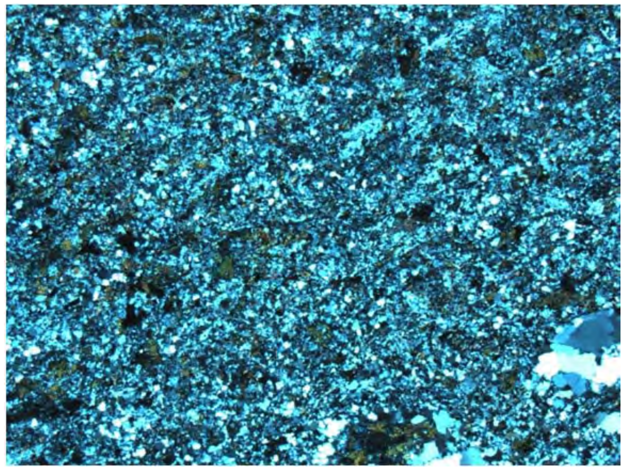


Figure 49: Sample 11006 under Cross Polarized Light. 4.5mm

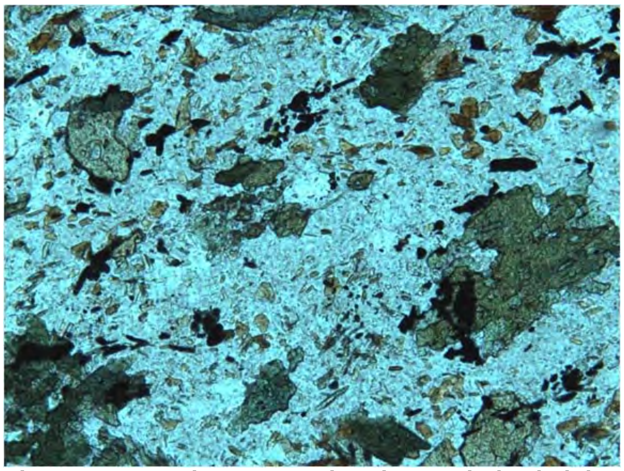


Figure 50: Sample 11006 under Plane Polarized Light. 1.1mm

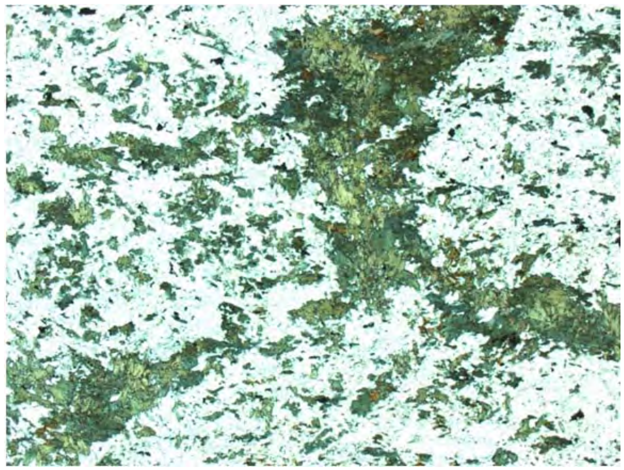


Figure 51: Sample 11006 under Plane Polarized Light. 1.1mm

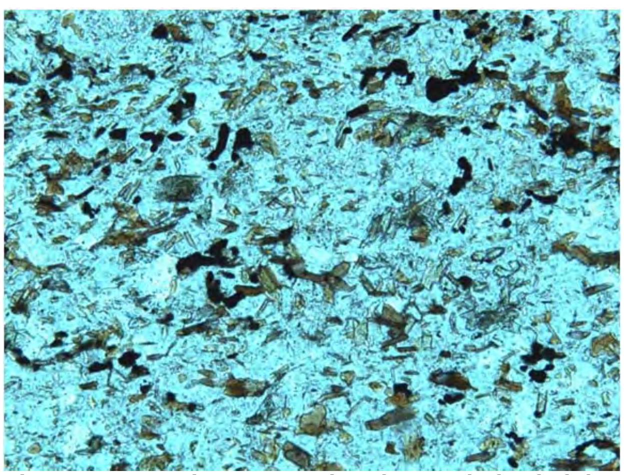


Figure 52: Sample 11006 under Plane Polarized Light. 1.1mm

Appendix C-7: Sample 11007

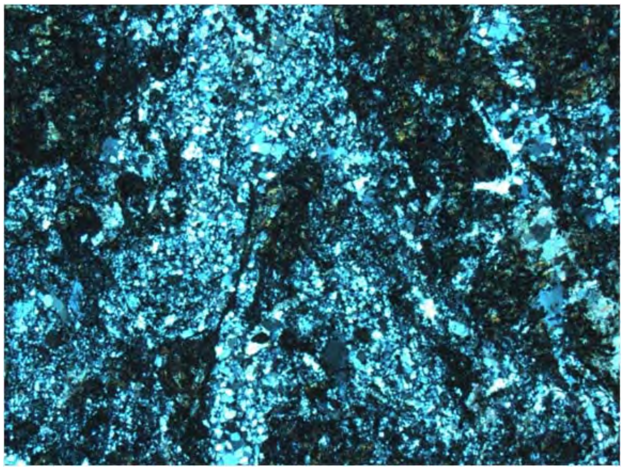


Figure 53: Sample 11007 under Cross Polarized Light. 4.5mm

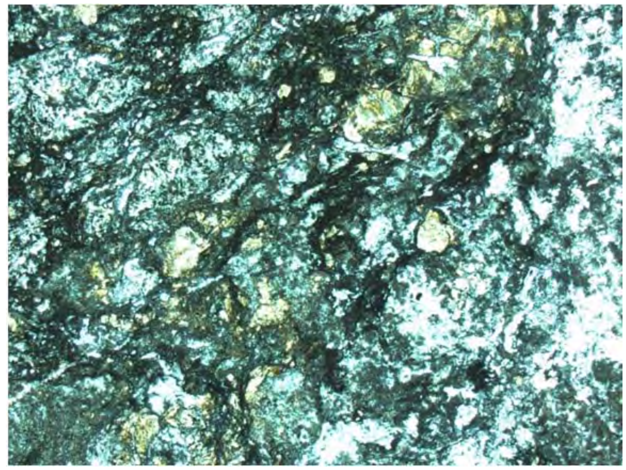


Figure 54: Sample 11007 under Plane Polarized Light. 4.5mm

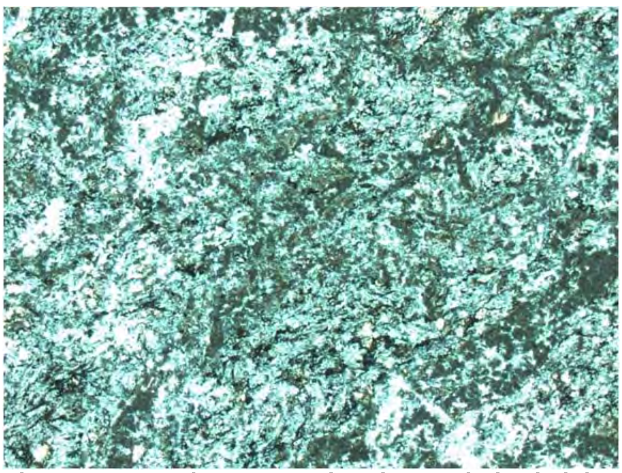


Figure 55: Sample 11007 under Plane Polarized Light. 4.5mm

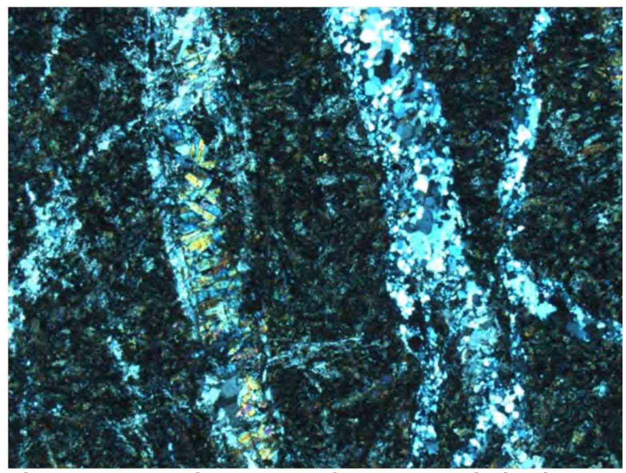


Figure 56: Sample 11007 under Cross Polarized Light. 4.5mm

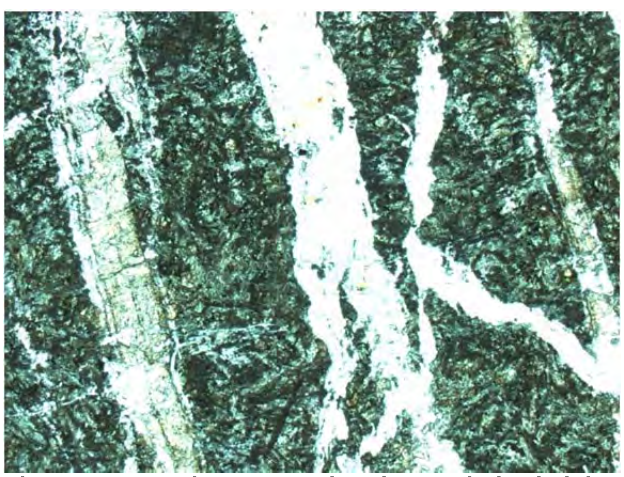


Figure 57: Sample 11007 under Plane Polarized Light. 4.5mm

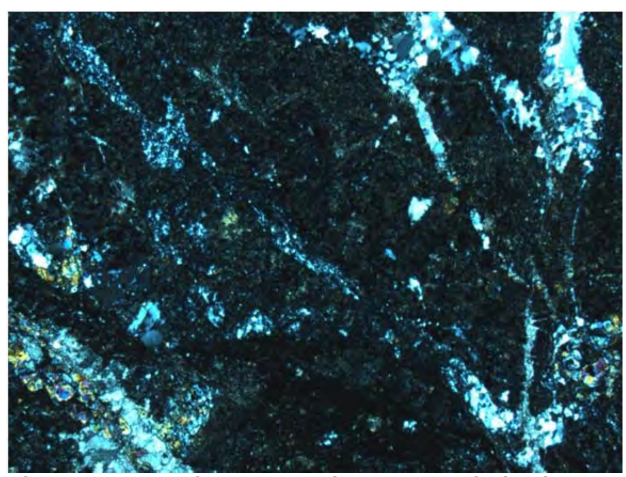


Figure 58: Sample 11007 under Cross Polarized Light. 4.5mm

Appendix C-8: Sample 11008

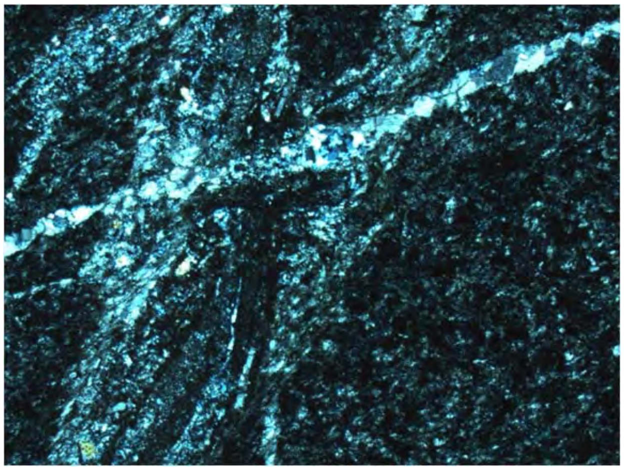


Figure 59: Sample 11008 under Cross Polarized Light. 4.5mm

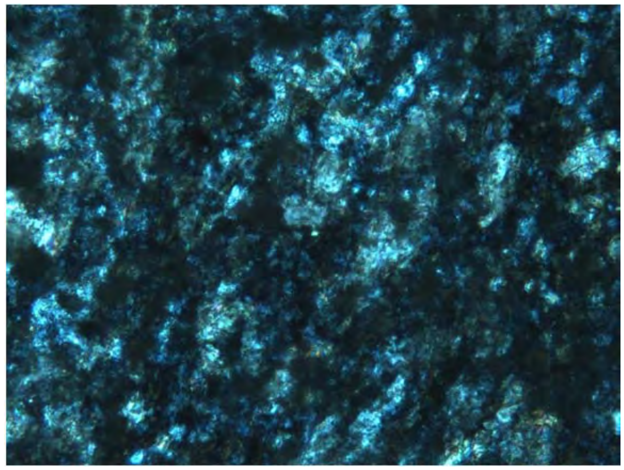


Figure 60: Sample 11008 under Cross Polarized Light. 0.75mm

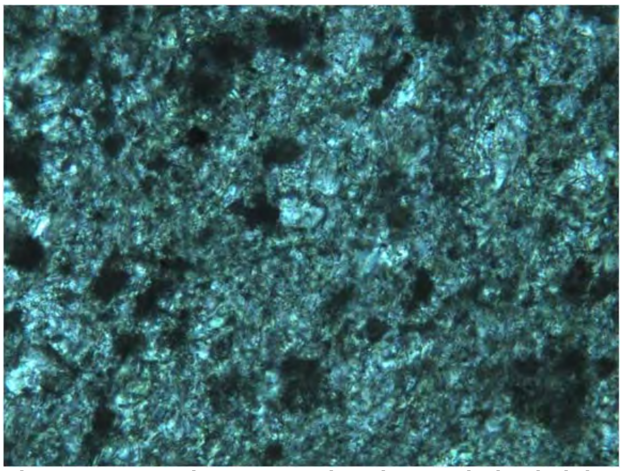


Figure 61: Sample 11008 under Plane Polarized Light. 0.75mm

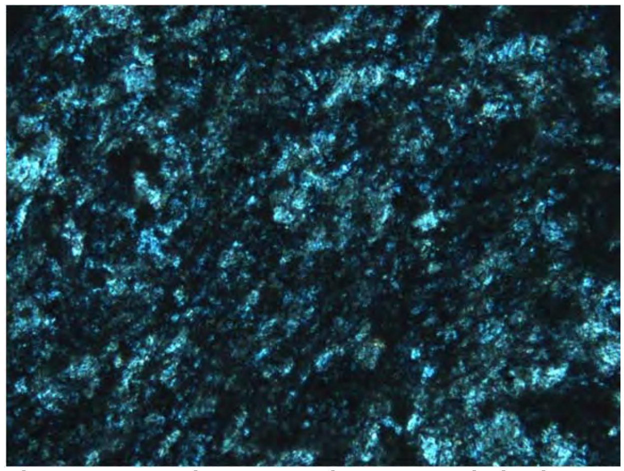


Figure 62: Sample 11008 under Cross Polarized Light. 1.1mm

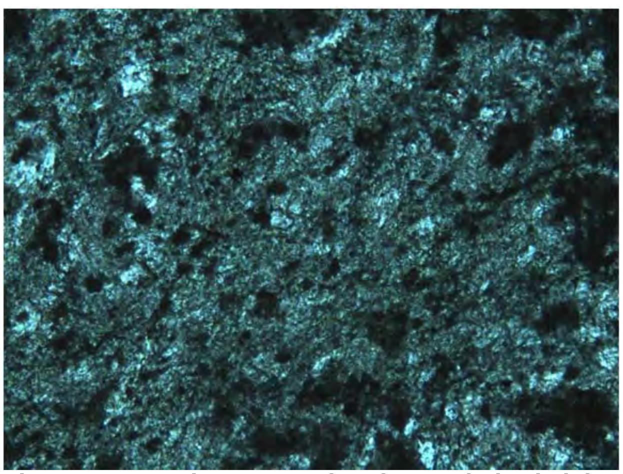


Figure 63: Sample 11008 under Plane Polarized Light. 1.1mm

Appendix C-9: Sample 11009

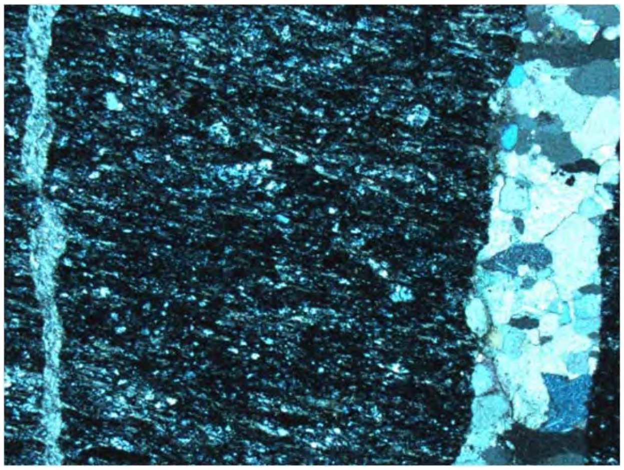


Figure 64: Sample 11009 under Cross Polarized Light. 4.5mm

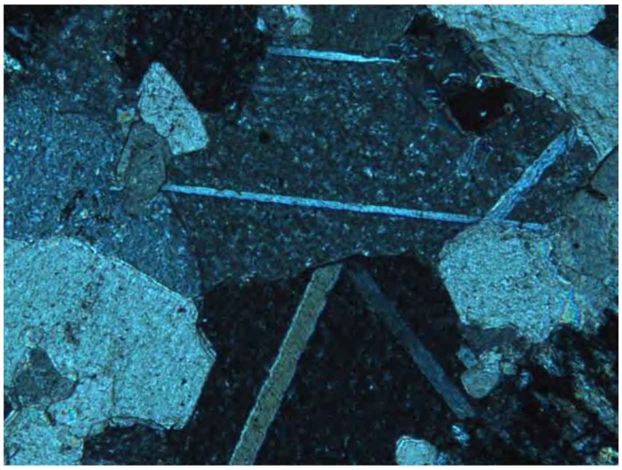


Figure 65: Sample 11009 under Cross Polarized Light. 1.1mm

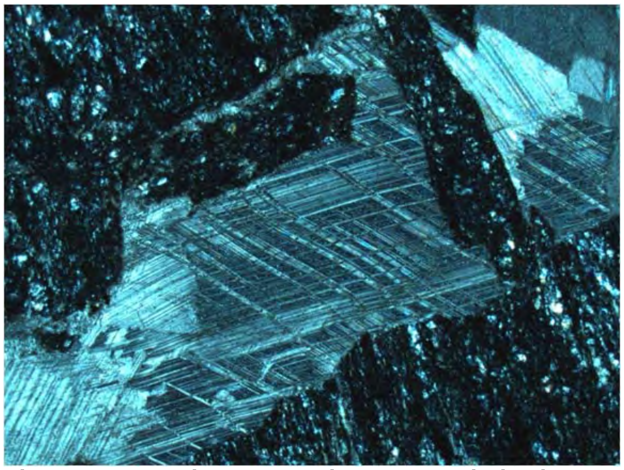


Figure 66: Sample 11009 under Cross Polarized Light. 4.5mm

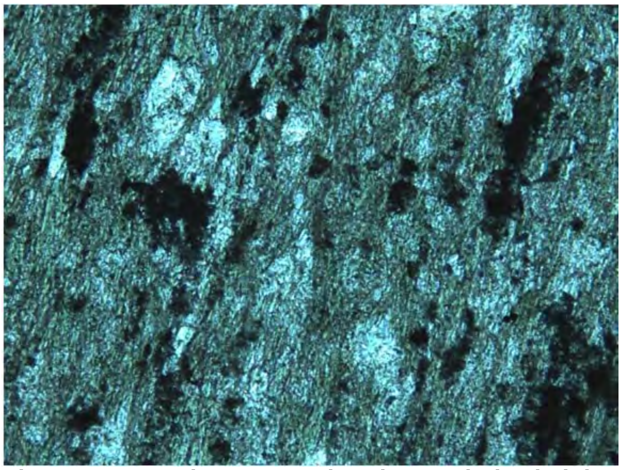


Figure 67: Sample 11009 under Plane Polarized Light. 1.1mm

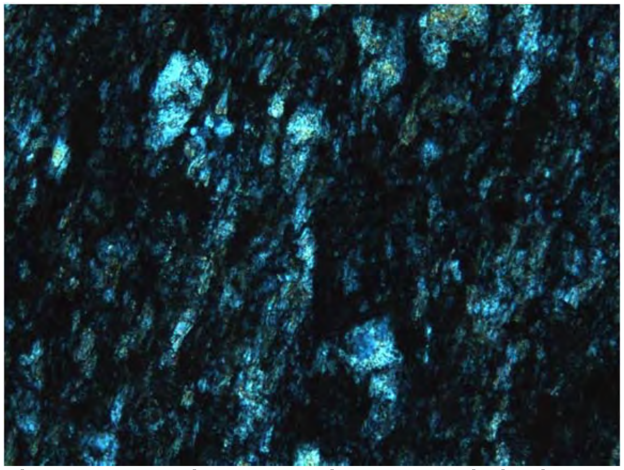


Figure 68: Sample 11009 under Cross Polarized Light. 1.1mm

Appendix C-10: Sample 11010

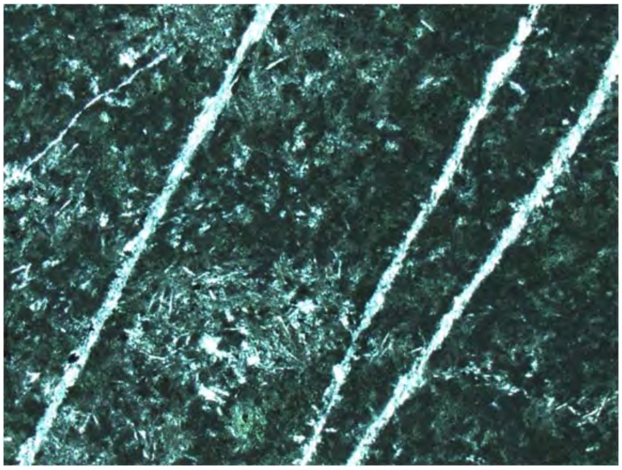


Figure 69: Sample 11010 under Plane Polarized Light. 4.5mm

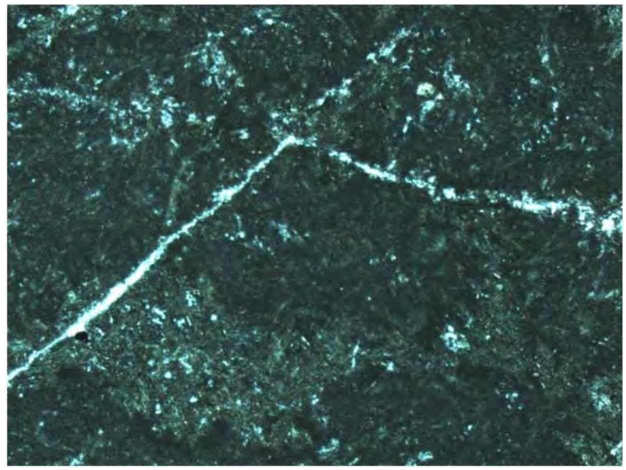


Figure 70: Sample 11010 under Plane Polarized Light. 4.5mm

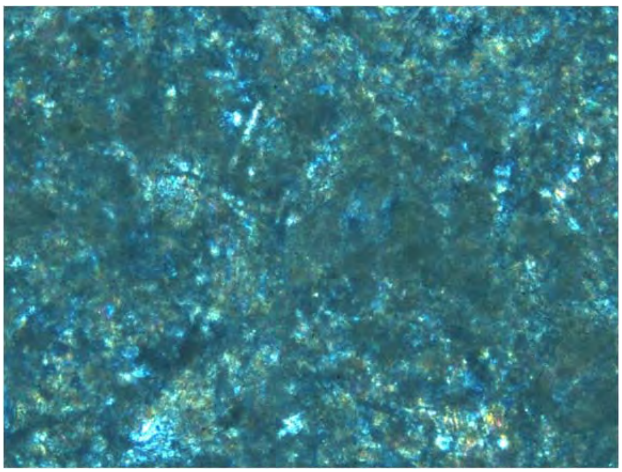


Figure 71: Sample 11010 under Cross Polarized Light. 1.1mm

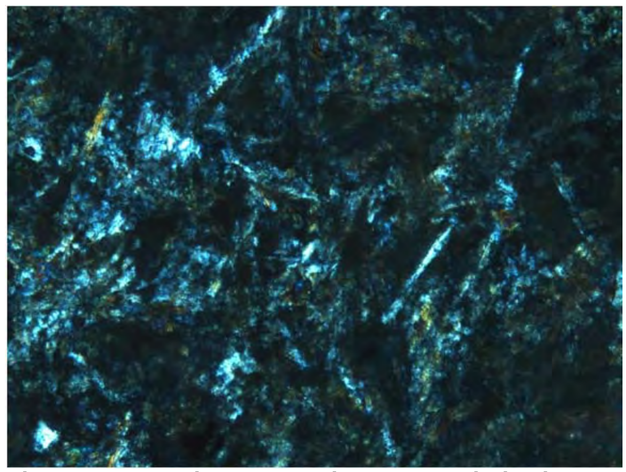


Figure 72: Sample 11010 under Cross Polarized Light. 1.1mm

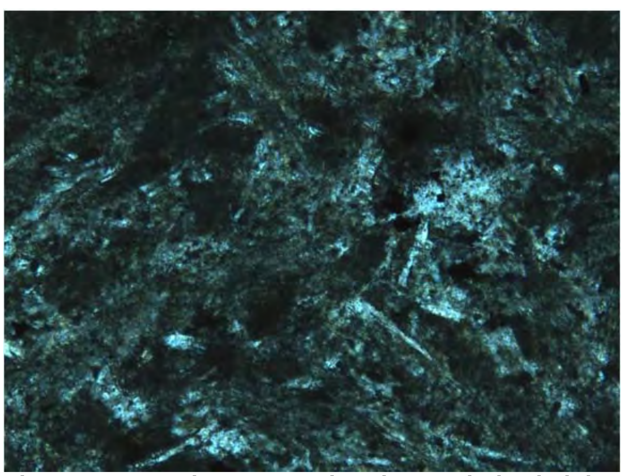


Figure 73: Sample 11010 under Plane Polarized Light. 1.1mm

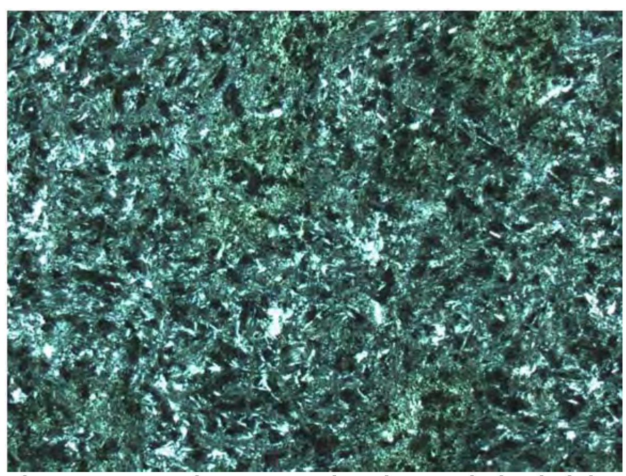


Figure 74: Sample 11010 under Plane Polarized Light. 4.5mm

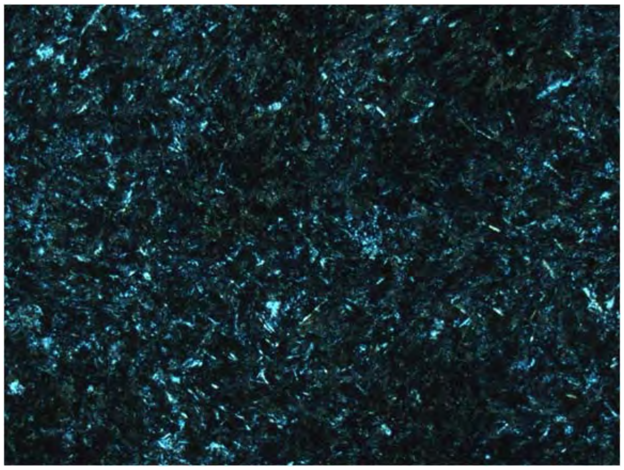


Figure 75: Sample 11010 under Cross Polarized Light. 4.5mm

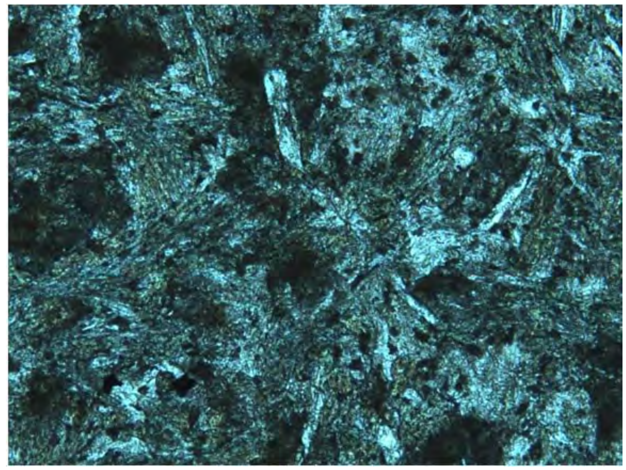


Figure 76: Sample 11010 under Cross Polarized Light. 1.1mm

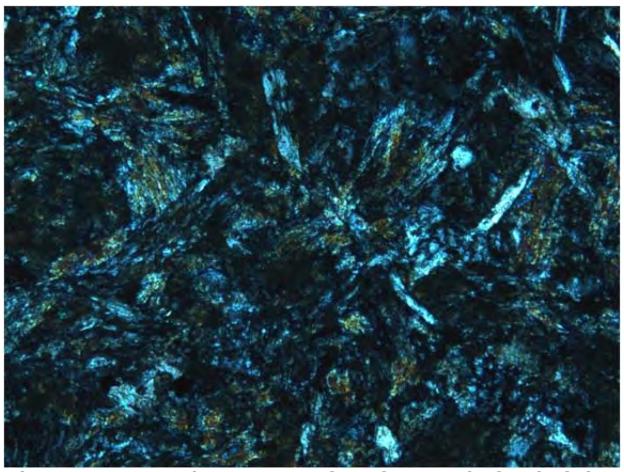


Figure 77: Sample 11010 under Plane Polarized Light. 1.1mm

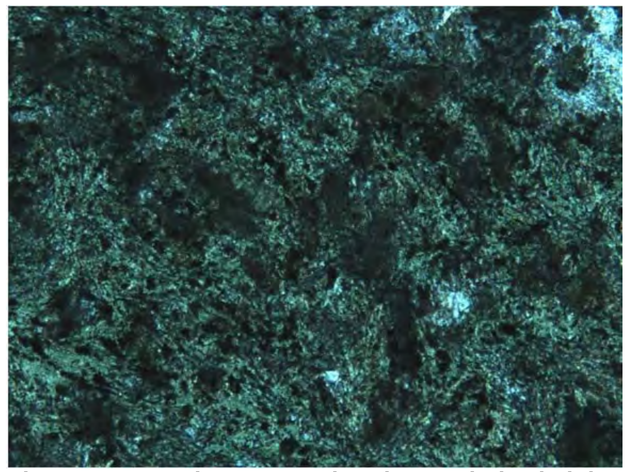


Figure 78: Sample 11010 under Plane Polarized Light. 1.1mm

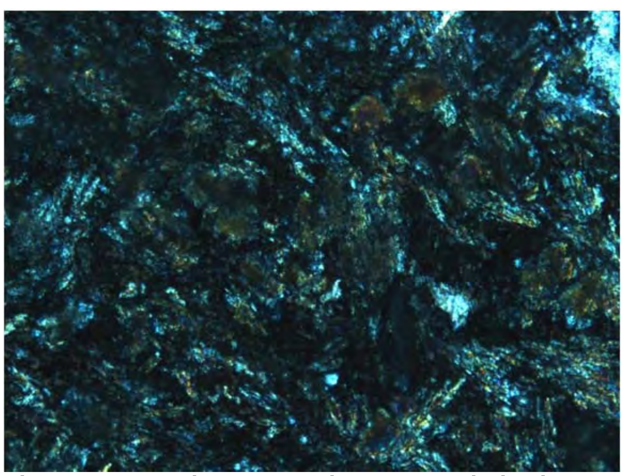


Figure 79: Sample 11010 under Cross Polarized Light. 1.1mm

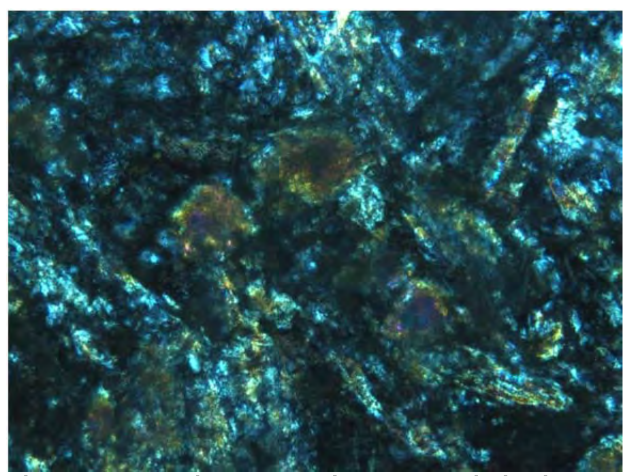


Figure 80: Sample 11010 under Cross Polarized Light. 0.75mm

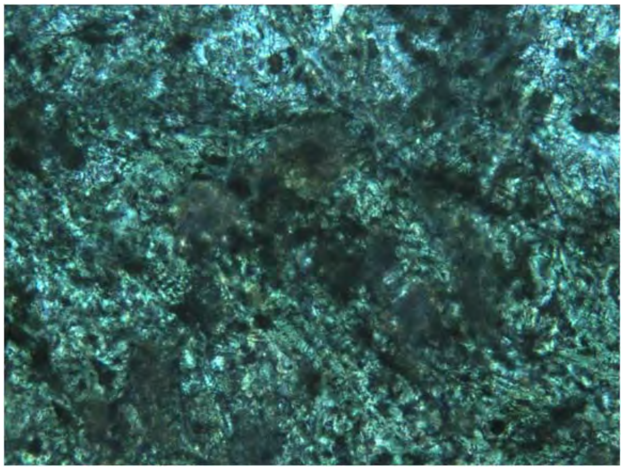


Figure 81: Sample 11010 under Plane Polarized Light. 0.75mm

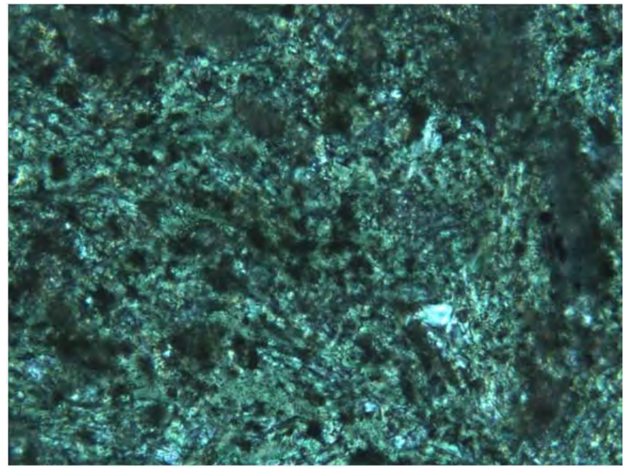


Figure 82: Sample 11010 under Plane Polarized Light. 0.75mm

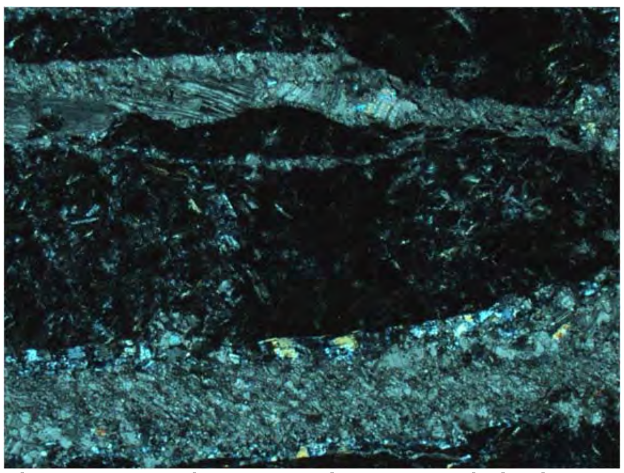


Figure 83: Sample 11010 under Cross Polarized Light. 4.5mm

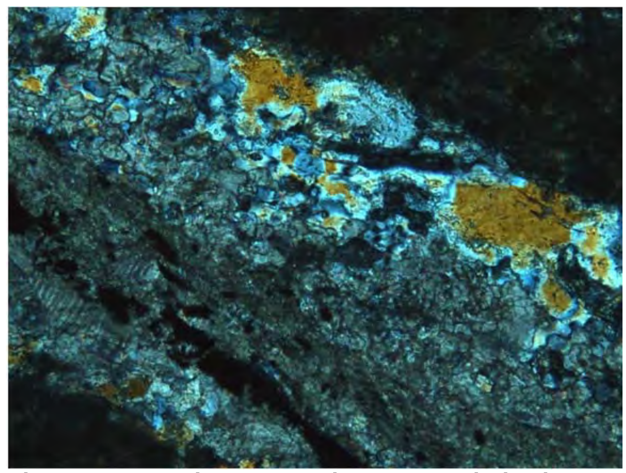


Figure 84: Sample 11010 under Cross Polarized Light. 1.1mm

Appendix C-11: Sample 11011

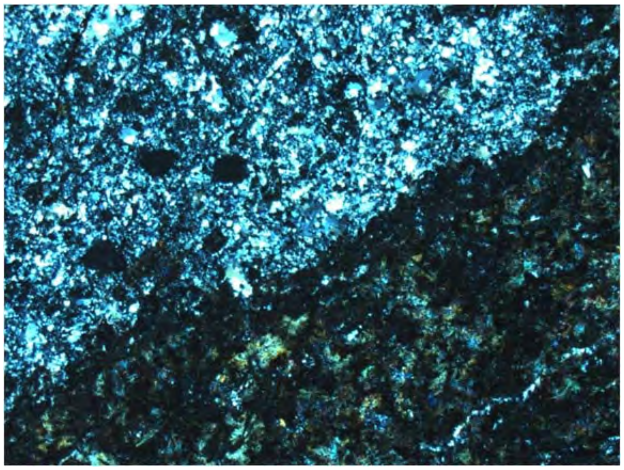


Figure 85: Sample 11011 under Cross Polarized Light. 4.5mm

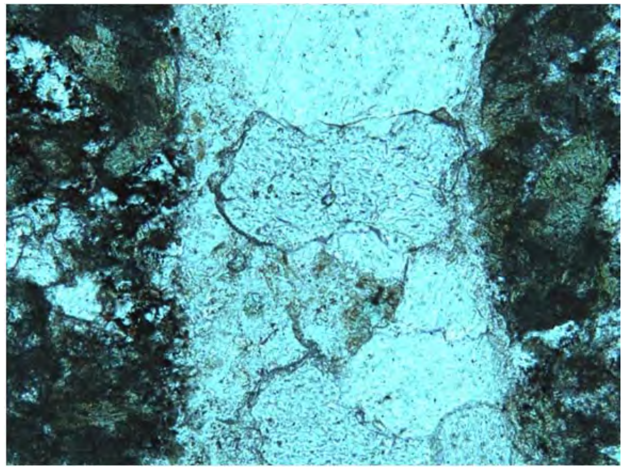


Figure 86: Sample 11011 under Plane Polarized Light. 1.1mm

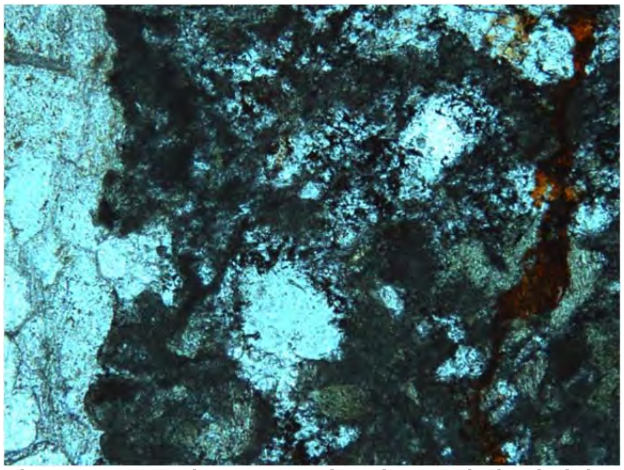


Figure 87: Sample 11011 under Plane Polarized Light. 1.1mm

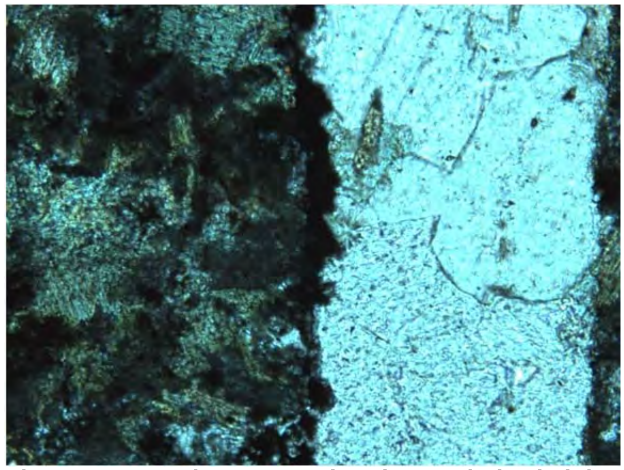


Figure 88: Sample 11011 under Plane Polarized Light. 1.1mm

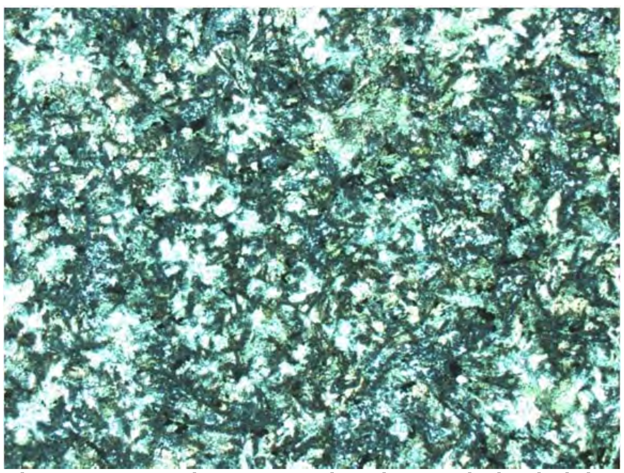


Figure 89: Sample 11011 under Plane Polarized Light. 4.5mm

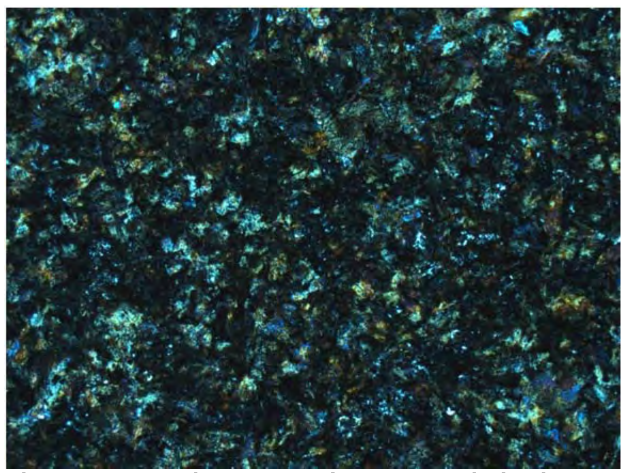


Figure 90: Sample 11011 under Cross Polarized Light. 4.5mm

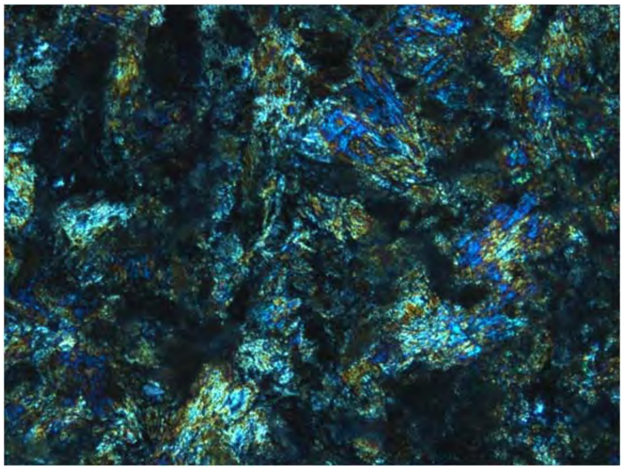


Figure 91: Sample 11011 under Cross Polarized Light. 1.1mm

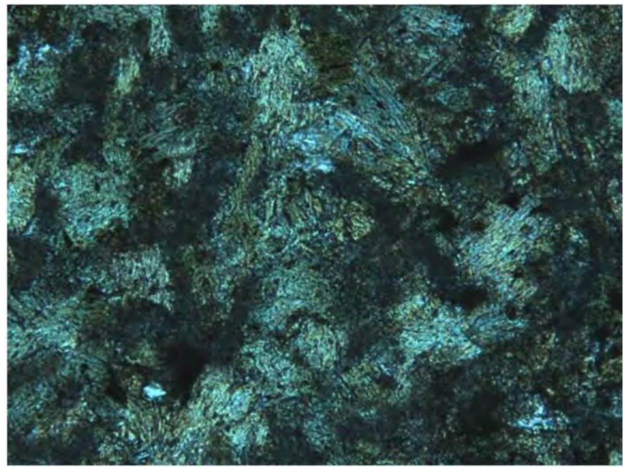


Figure 92: Sample 11011 under Plane Polarized Light. 1.1mm

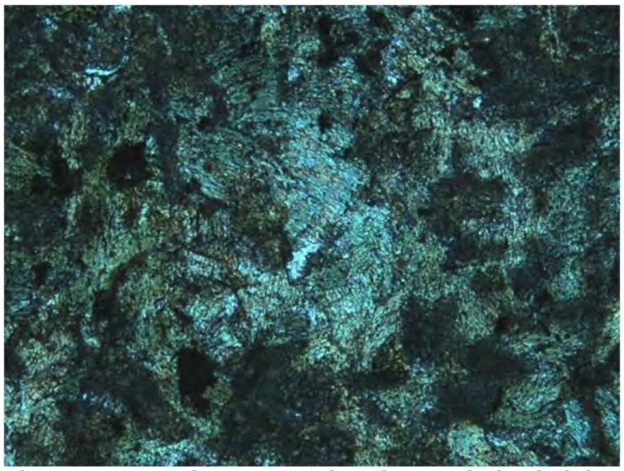


Figure 93: Sample 11011 under Plane Polarized Light. 1.1mm

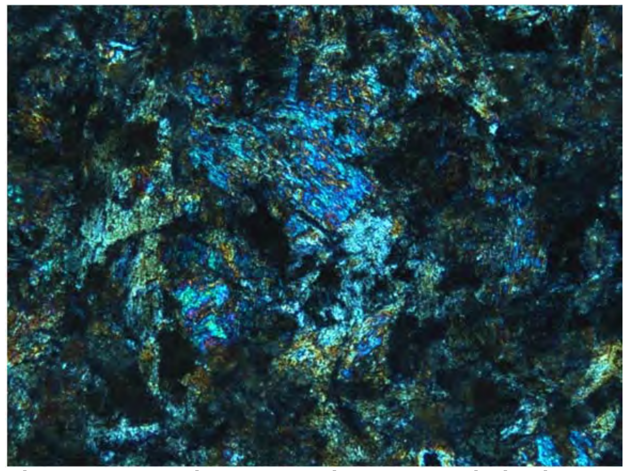


Figure 94: Sample 11011 under Cross Polarized Light. 1.1mm

Appendix B: Underground Photographs

Photo 1: March 2, 2011; Typical frost build-up on underground freeze pipe heads.

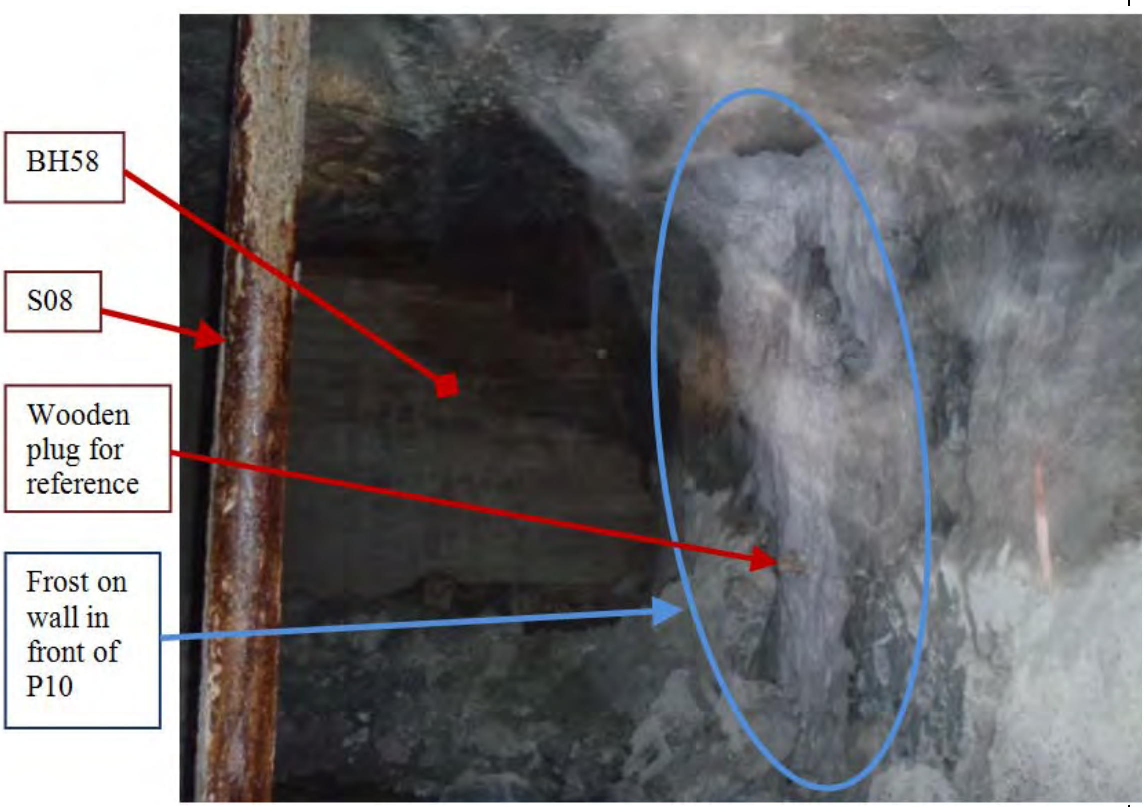


Photo 2: March 10 2011; View of frost on the drift wall on the 2nd Level near BH58 looking toward P10 prior to its exposure. The exposed pipe on the left is S08.

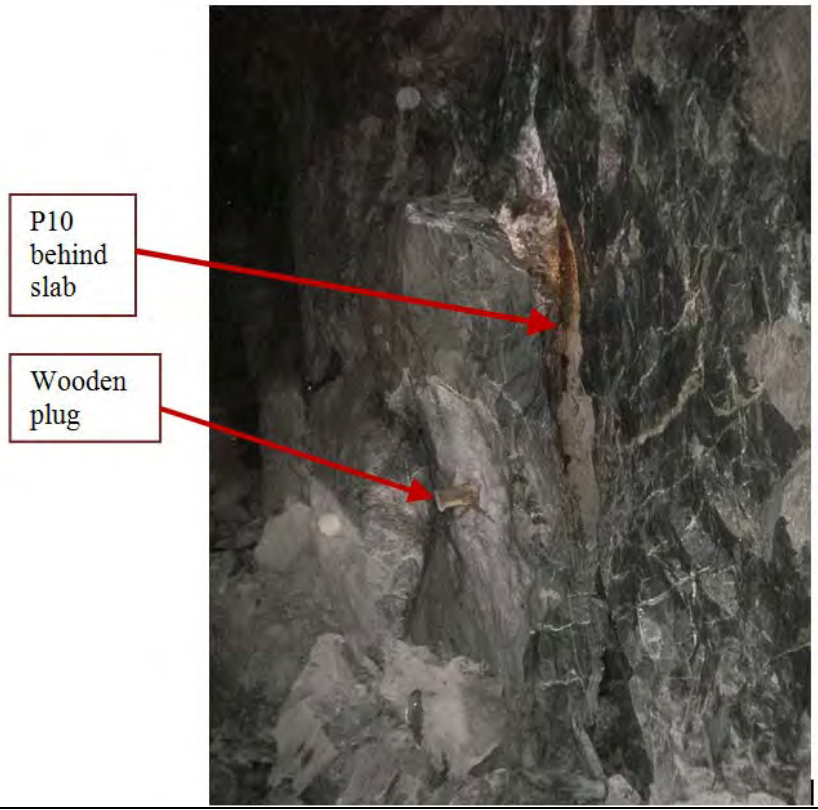


Photo 3: March 16, 2011; View of slab that has come off the drift wall exposing P10.

Photo 4: March 21, 2011; View of grout found issuing from P10.

Photo 5: March 21, 2011; View of exposed freeze pipe P10.

Photo 6: Mar 23, 2011; Typical frost build-up on underground freeze pipe heads.

Photo 7: April 18, 2011.

Photo 8: April 18, 2011.

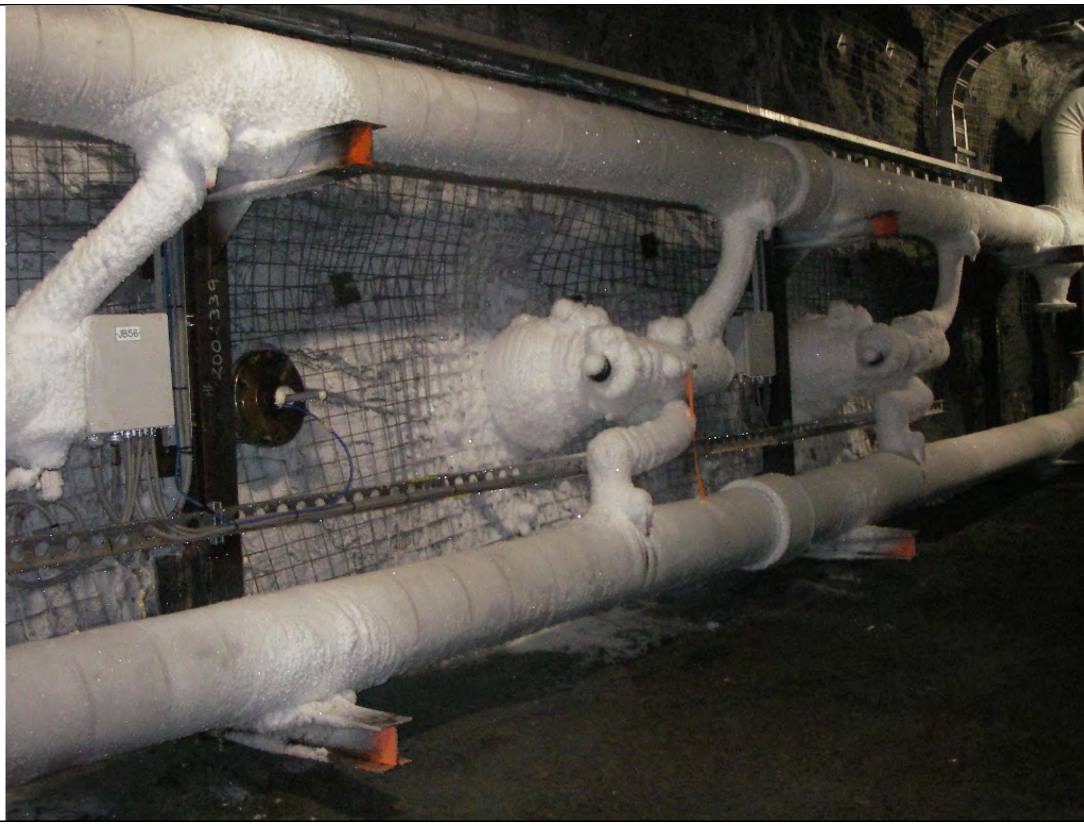


Photo 9: May 18, 2011.

Photo 10: May 25, 2011; Frost build-up on Bulkhead #58

Photo 11: June 24, 2011.

Photo 12: June 24, 2011.

Photo 13: July 29, 2001; Frost build-up on Bulkhead 61 on 1st Level.

Photo 14: August 10, 2011.

Photo 15: September 9, 2011

Photo 16: September 9, 2011; Bulkhead #58.