Skidegate Quarry

Skeena District

Metal Leaching and Acid Rock Drainage Prediction and Prevention Plan Report
July 2017

Prepared by:
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Reviewed by:
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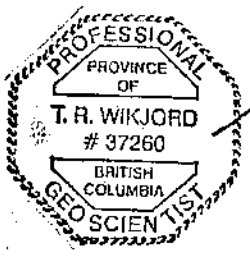


July 25/2017

1.0 Introduction

The following Metal Leaching and Acid Rock Drainage (ML/ARD) Prediction and Prevention Plan Report (PPPR) has been completed for Skidegate Quarry (the site) at the request of Brian Lomas – Area Roads Manager of Haida Gwaii in the Skeena District. Skidegate Quarry is a privately owned quarry source located ~2.5km northeast of the Skidegate Landing Ferry Terminal along the Hwy 16 (Figure 1). Ministry of Transportation and Infrastructure (MoTI) seeks this site for the purchase of rip rap material to aid in erosion control.

2.0 Regional Geology

The Skidegate Quarry is hosted by the Yakoun Formation as defined by the BC Geological Survey Mapping and the Geological Survey of Canada Mapping. The Yakoun Formation is a Mid-Late Jurassic sequence of porphyritic andesite, agglomerate and flows, calcareous scoraceous lapilli tuffs, and volcanic sandstone with local 'pepperite'.

3.0 Local Geology

The geology of the quarry is observed to be massive to porphyritic grey-grey blue andesite with trace pyrite. The rock hosts 0.1-2cm wide veins of carbonate minerals, observed to be primarily calcite in hand sample (vigorous effervescence upon application of dilute hydrochloric acid). The andesite was moderately jointed and had carbonate coating on most joint and fracture faces. The andesite has undergone hydrothermal alteration, as observed by the calcite veining within the rock mass. The andesite has localized epidote alterations as well as a local presence of hematite, magnetite, and plagioclase feldspars.

Samples ranged from having trace amounts of disseminated pyrite and other fine grained sulphide minerals (visible to naked eye) to occasional iron oxide staining on weathered faces.

4.0 Site Investigation

A site investigation was completed on May 16, 2017 by Ragan Danford, GIT. The field investigation included a visual inspection of rock faces and previously blasted rock to understand the variability of geology across the site. Samples from the quarry faces (including blasted material, and a crushed sample) were collected and analyzed to complete this PPPR.

Samples were collected to represent the geological variation observed at the site. Geological descriptions were completed and photos were taken for each sample collected (Appendix C -- Photos and Rock Descriptions). SQ1701 was sampled from a freshly crushed stockpile (the contractor claimed the product had been produced within one week prior to sample collection). The crushed product was manufactured from the crushing of all current blast material and could be considered a representable whole bulk sample of blasted material within the quarry. A hand lens with 20x magnification, scriber with magnet, and 10% dilute hydrochloric acid were used to assist in preliminary field mineral identification. Four samples were submitted for ML/ARD testing.

Sample Identifier		UTM 9N
SQ1701	Crushed stockpile	300252.73mE / 5905668.64mN
SQ1702	Blasted bench 1	300251.92mE / 5905626.06mN
SQ1703	Blasted bench 2	300252.30mE / 5905562.63mN
SQ1704	Unblasted peak closest to highway	300338.59mE / 5905612.87mN

5.0 Lab Methods

Acid Base Accounting (ABA), Trace Elements by aqua regia digestion with ICP-MS finish and X-Ray Diffraction with Reitveld Refinement (XRD-RR) were completed by SGS Laboratories in Vancouver. The following parameters were analyzed for Modified ABA analysis (Merchant and Lawrence, 1991):

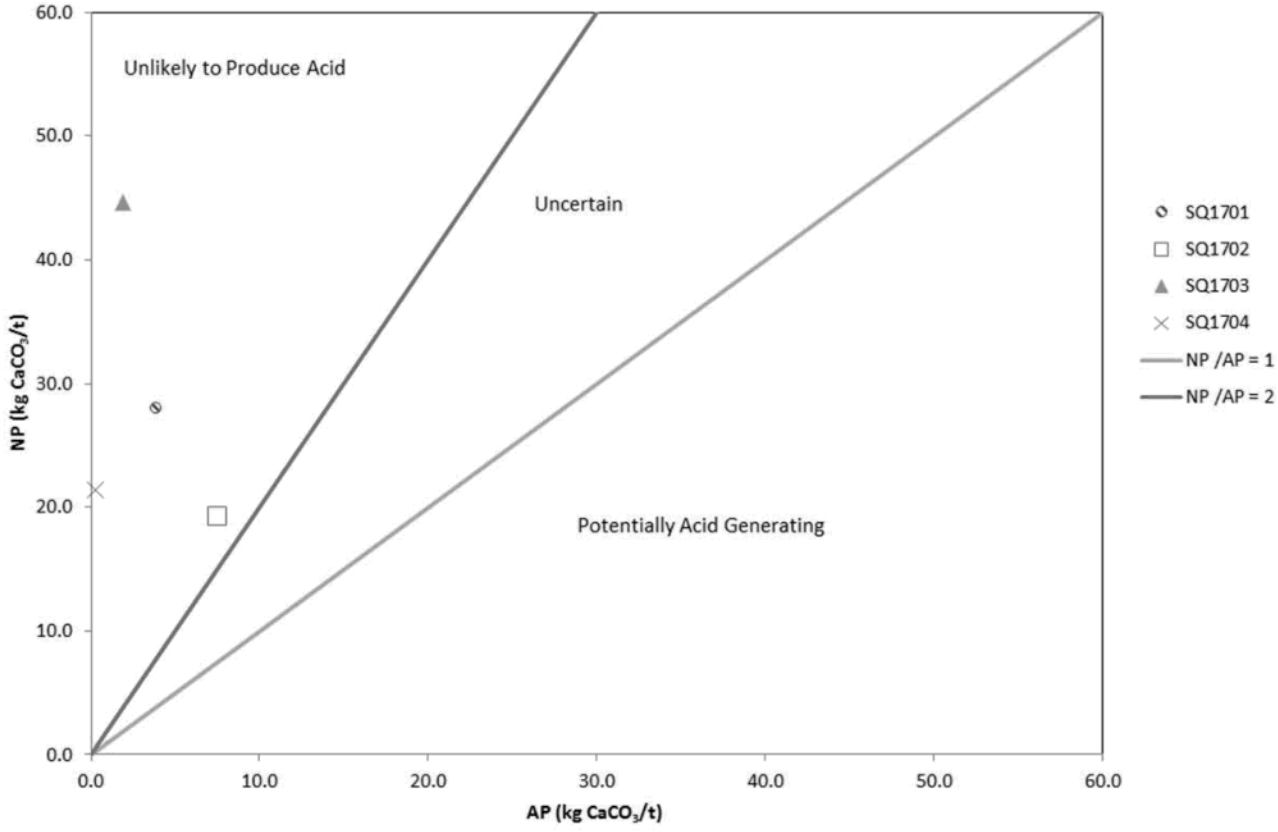
- Paste pH
- Total Sulphur by Leco
- Sulphate sulphur by HCL
- Sulphide sulphur by HNO3
- Insoluble sulphur by difference (total S-(sulphate S + Sulphide S))
- Total inorganic carbon

6.0 Laboratory Results

6.1 Acid Base Accounting

Four samples were analyzed using ABA. ABA data for this investigation indicate that the rock sampled is unlikely to generate acidic drainage and is classified as Not Potentially Acid Generating (Non-PAG) as shown in Appendix B Table 2 and is unlikely to produce acid (Appendix B Table 3) The Non-PAG classification of this rock is the result of low sulphide and non-extractable sulphur concentrations (0.005-0.225 wt%) and sufficient neutralization capacity (11.8-42.9 Kg $CaCO_3$/tonne). The Neutralization Potential Ratio (NPR) ratio of Acid Potential (AP) to Neutralization Potential (NP) is greater than 2 for all samples (Graph 1).

Graph 1: Modified Acid-Base Accounting Test Used on Skidegate Quarry Grab Samples to Determine the Potential of Acid Rock Generation



6.2 Mineralogy by X-Ray Diffraction

Mineralogy by XRD-RR was completed on four samples. The results of the mineralogical analysis by XRD-RR identified a rock mass of primarily plagioclase feldspar minerals, rich in silicate oxides and a presence of local hydrothermal alterations within the greenschist facies. No, to very minimal concentrations of sulphide minerals were identified (Appendix B Table 4) and confirms the ABA results.

6.3 Trace Elements

Trace elements were analyzed on four samples using the aqua regia leach followed by ICP-MS for 37 elements. Trace element data was compared to average crustal abundancies for whole crust and basaltic crust (Turekian and Wedepohl, 1961) to identify potential elements of concern for metal leaching. All concentrations were less than ten times the average crustal abundance therefore concentrations are not interpreted to be anomalous. For this reason, the trace element concentrations observed are within ten times the average crustal abundance for the observed geology.

7.0 Closure

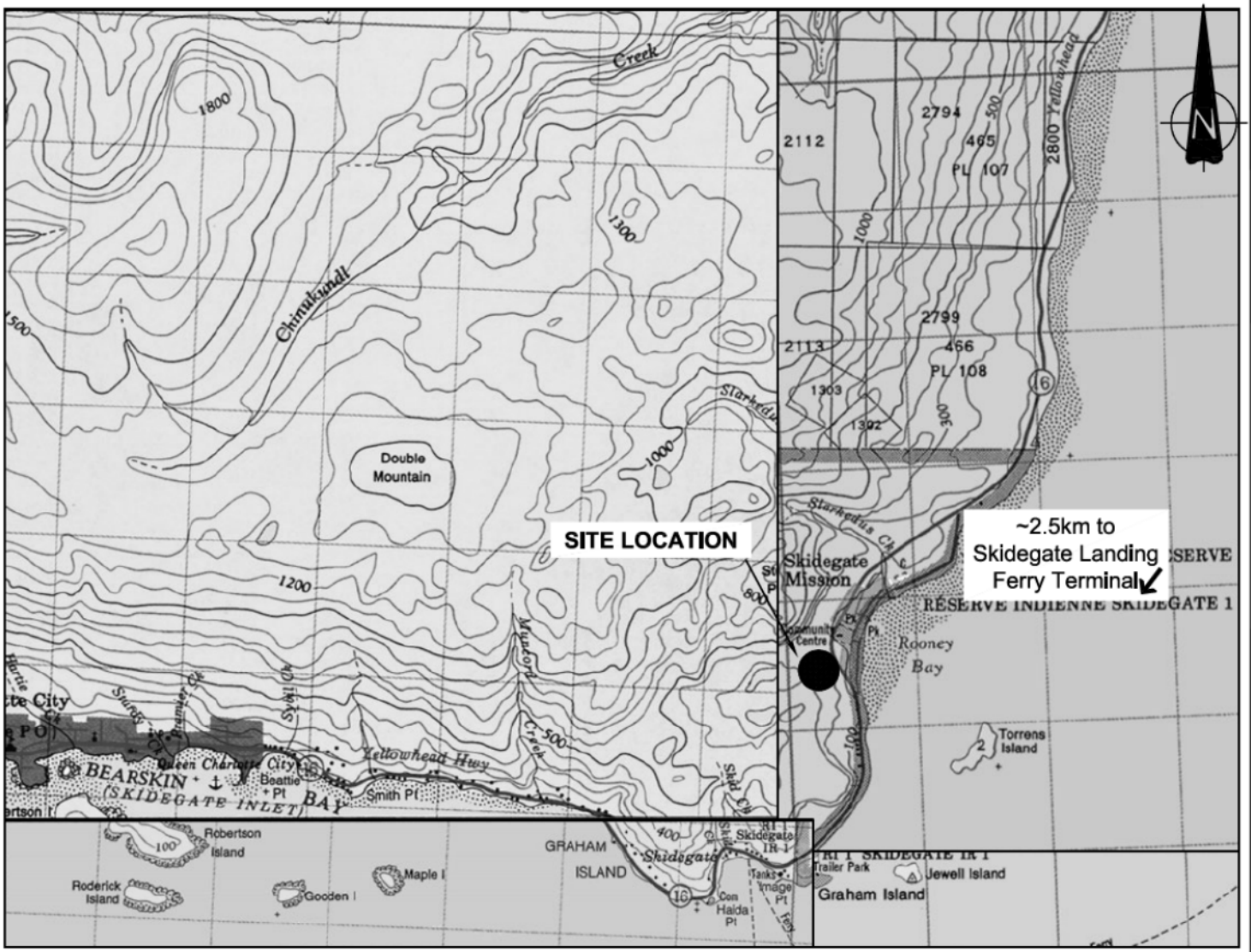
Based on the data available and the guidelines outlined in the MoTI Technical Circular (T-Circ 04/13), the quarry material at Skidegate Quarry presents a low risk of metal leaching and acid rock drainage for the use of rip rap.

APPENDIX A – Location Plan

APPENDIX B – Analytical Data

APPENDIX C – Photos and Sample Descriptions

APPENDIX A – Location Map



Location Plan: NTS Mapsheets 103G5, 103G4, 103F1, 103F8
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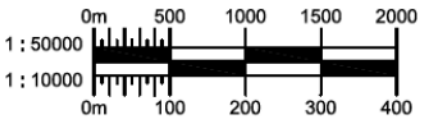

Google Earth Image:
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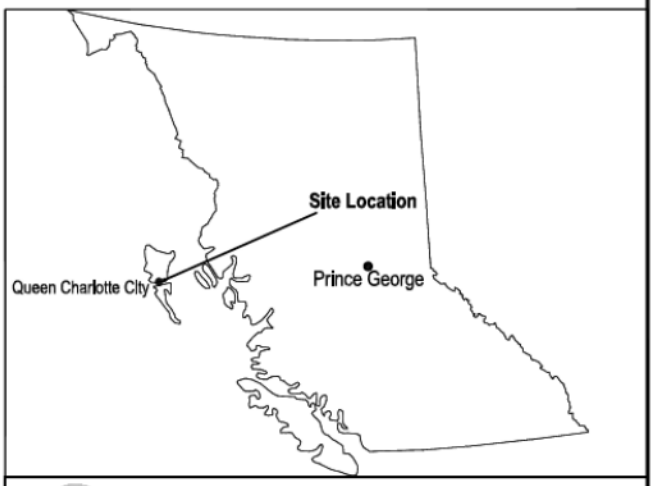

BRITISH COLUMBIA

MInIstry of Transportation and Infrastructure
Northern Region
Geotechnical and Materials Branch

LOCATION PLAN (2017)
SKIDEGATE PRIVATE QUARRY
SKEENA DISTRICT

DRAWN BY:	PROJECTION:		SCALE:
R.Danford	UTM Zone 9		AS SHOWN
CHECKED BY:	DATUM:		DATE:
T.Wikjord	NAD83		11 July 2017
FILE No.	PROJECT No.	REG.	DRAWING No.
skidegateprivatequarry-locationplan-july2017.dwg -		NR	FIGURE 1

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This drawing was originally produced in colour.

APPENDIX B – Analytical Data

Table 1: Trace Elemental Analysis

Sample ID	Ag	Al	Ba	Ca	Cr	Cu	Fe	K	Li	Mg	Mn	Na	Ni	P	S	Sr	Ti	V	Zn
	ppm	%	ppm	%	ppm	ppm	%	%	ppm	%	ppm	%	ppm	%	%	ppm	%	ppm	ppm
LOD	0.01	0.01	5	0.01	1	0.5	0.01	0.01	1	0.01	2	0.01	0.5	0.005	0.01	0.5	0.01	1	1
SQ1701	0.06	4.93	39	3.44	42	**66.5**	**5.97**	0.08	7	**2.57**	1100	0.28	13.7	0.07	**0.11**	132	0.4	**213**	**73**
SQ1702	0.04	4.75	29	3.35	39	**79.6**	**6.74**	0.07	10	**2.39**	1050	0.29	11.6	0.07	**0.21**	82.4	0.43	**223**	53
SQ1703	0.03	4.73	37	**3.99**	43	**74.6**	**5.8**	0.04	5	**2.63**	950	0.34	24.5	0.07	**0.05**	170	0.36	**206**	70
SQ1704	0.03	5.31	62	3.52	29	50.4	**5.69**	0.1	8	1.94	865	0.28	4.9	0.08	<0.01	170	0.33	**199**	66
Crustal Average Abundance *	0.07	8.13	330	3.63	100	55	5	2.59	20	2.09	1500	2.83	75	0.1	0.03	375	0.44	175	70
10X Average Crustal Abundance *	0.7	81.3	3300	36.3	1000	550	50	25.9	200	20.9	15000	28.3	750	1	0.3	3750	4.4	1750	700

Sample ID	Zr	As	Be	Bi	Cd	Ce	Co	Cs	Ga	Ge	Hf	Hg	In	La	Lu	Mo	Nb	Pb	Rb
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
LOD	0.5	1	0.1	0.02	0.01	0.05	0.1	0.05	0.1	0.1	0.05	0.01	0.02	0.1	0.01	0.05	0.05	0.2	0.2
SQ1701	30.6	**2**	0.4	0.02	0.09	12.5	**26**	0.46	10.8	0.3	0.83	0.02	0.05	5.3	0.24	1.15	0.31	5	0.9
SQ1702	29.3	**2**	0.5	0.04	0.11	12.5	**28.5**	0.62	12.9	0.4	0.82	0.01	0.05	5.5	0.23	0.99	0.16	4	1.4
SQ1703	30.1	1	0.4	<0.02	0.05	10.7	**29**	<0.05	9.4	0.3	0.72	0.02	0.04	4.6	0.23	0.93	0.15	4.3	0.5
SQ1704	33.1	<1	0.5	<0.02	0.09	14.4	19.8	0.07	11.1	0.2	1	<0.01	0.05	6.3	0.26	0.78	0.16	4.3	1.9
Average Crustal Abundance *	165	1.8	2.8	0.2	0.2	60	25	3	15	1.5	3	0.08	0.1	30	0.5	1.5	20	13	90
10X Average Crustal Abundance *	1650	18	28	2	2	600	250	30	150	15	30	0.8	1	300	5	15	200	130	900

Sample ID	Sb	Sc	Se	Sn	Ta	Tb	Te	Th	Tl	U	W	Yb	Y
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
LOD	0.05	0.1	**1**	**0.3**	0.05	0.02	0.05	0.1	0.02	0.05	**0.1**	0.1	0.05
SQ1701	0.1	**21.4**	<1	**0.6**	<0.05	0.45	0.07	0.7	0.03	0.27	**0.1**	1.5	14.8
SQ1702	0.1	**21.1**	<1	**0.5**	<0.05	0.46	<0.05	0.5	0.03	0.24	<0.1	1.4	14.5
SQ1703	0.12	**19.7**	<1	**0.5**	<0.05	0.41	<0.05	0.5	<0.02	0.23	<0.1	1.4	14.3
SQ1704	0.05	**21.6**	<1	**0.5**	<0.05	0.53	<0.05	0.7	<0.02	0.34	<0.1	1.6	16.7
Average Crustal Abundance *	0.2	22	0.05	2	2	0.9	0.01	4	0.5	1.8	1.5	3.4	33
10X Average Crustal Abundance *	2	220	0.5	20	20	9	0.1	40	5	18	15	34	330

Source*: Mason, B, and Moore, C. B., 1982, Principles of Geochemistry. Copyright © 1982 by John Wiley & Sons, Inc., New York

Bold Text indicates concentrations are greater than the average crustal abundance

Bold text and red highlight indicates concentrations are greater than 10X the average crustal abundance

Table 2: Generic Acid Base Accounting Screening Criteria (Price, 2009)

Classification	ARD Potential	Initial Screening Criteria	Comments
Potentially Acid Generating (PAG) or Acid Generating (AG)	Likely	NPR < 1	Acid generation is likely unless the sulphides are non-reactive or not acid generating
Uncertain (U) and requires further characterization	Uncertain	1 ≤ NPR ≤ 2	Possibly acid generation of 1) NP is insufficiently reactive or 2) NP is depleted at a faster rate than the sulphides
Not Potentially Acid Generating (non – PAG)	Unlikely	NPR > 2	Not potentially acid generating unless 1) significant oxidation of sulphides occurs on preferentially exposed grains within fractures, or 2) the sulphides are extremely reactive in combination with insufficiently reactive NP.

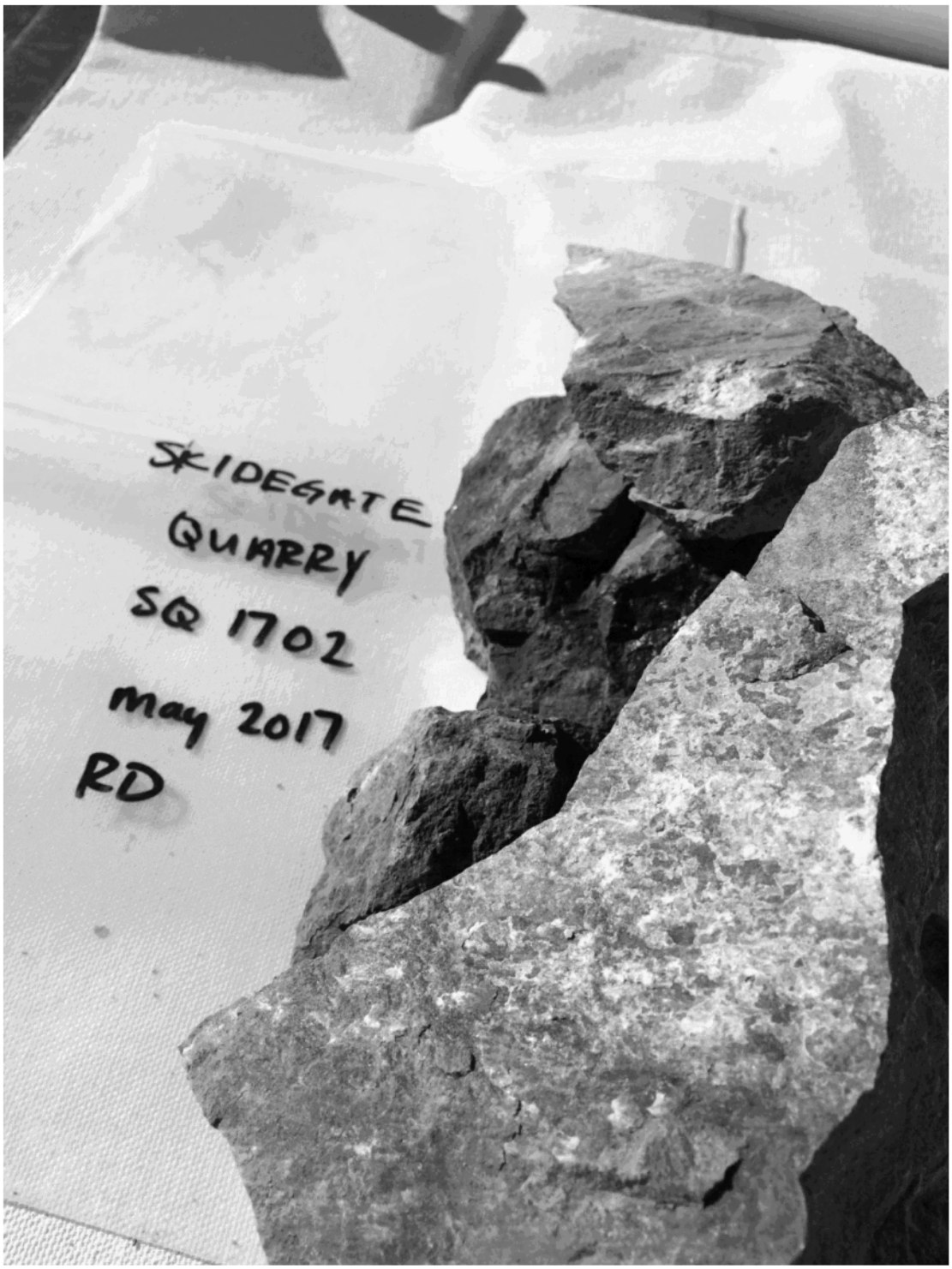
Table 3: Acid Base Accounting Summary

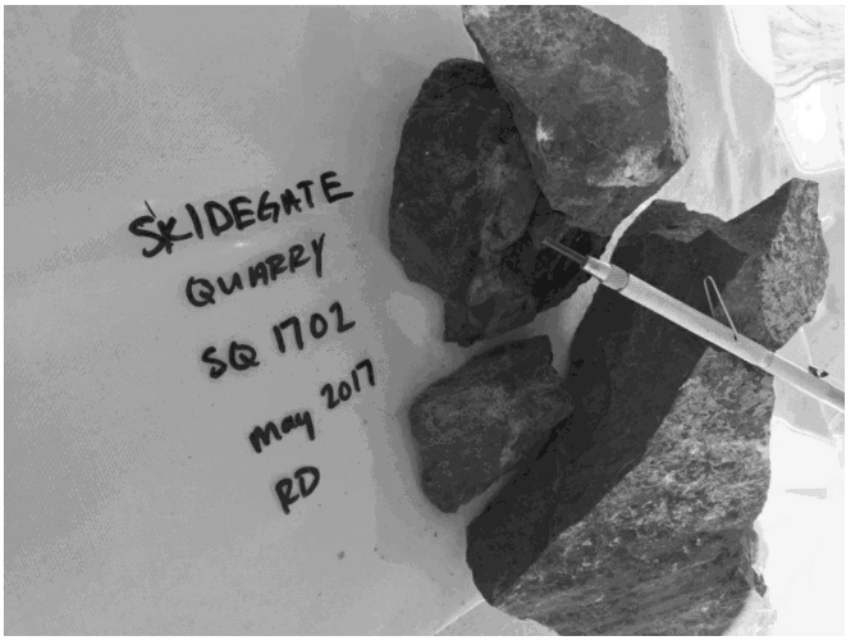
Sample ID	Fizz Rating	Paste pH	$CaCO_3$ Equiv.	Total S	Sulphate (HCl Extractable Sulphur)	Sulphide (HNO_3 Extractable Sulphur)	Non Extractable Sulphur (by diff.)	Acid Generation Potential (HNO_3 Extractable and Non-Extractable Sulphur*31.25)	Mod. ABA Neutralization Potential	Net Neutralization Potential	Neutralization Potential Ratio (NP/AP)	ARD Classification
Units	N/A	pH Units	Kg $CaCO_3$/T	wt%	wt%	wt%	wt%	Kg $CaCO_3$/T	Kg $CaCO_3$/T	Kg $CaCO_3$/T	N/A	N/A
SQ1701	NONE	8.55	10.8	0.098	<0.01	0.12	<0.02	3.8	28.1	24.4	7.4	Non-PAG
SQ1702	NONE	8.78	3.3	0.225	0.01	0.24	<0.02	7.5	19.3	11.8	2.6	Non-PAG
SQ1703	NONE	8.63	21.7	0.048	<0.01	0.06	<0.02	1.9	44.6	42.9	23.5	Non-PAG
SQ1704	NONE	8.36	10.8	<0.0005	<0.01	0.01	<0.02	0.3	21.4	21.4	71.3	Non-PAG
Detection Limit	N/A	N/A	*1.8*	*0.02*	*0.01*	*0.01*	*0.02*	*0.3*	*0.1*	*0.1*	*0.1*	N/A

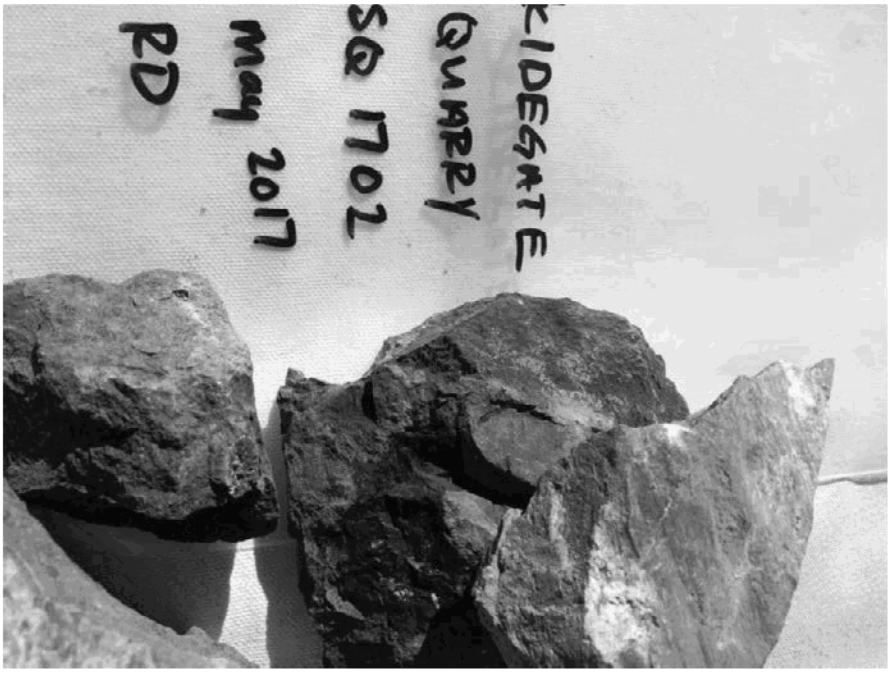
Table 4: Summary of Mineralogical Analyses by XRD-R

Mineral	Quartz	Andesine	Orthoclase	Chlorite	Diopside	Epidote	Montmorillonite	Magnetite	Prehnite	Albite	Anatase	Hematite	Pyrite
Formula	SiO_2	(NaSi, CaAl)$AlSi_2O_8$	$KAlSi_3O_8$	$(Fe,(Mg,Mn)_5,Al)(Si3Al)O_{10}(OH)_8$	$CaMgSi_2O_6$	$Ca_2(Al,Fe)Al_2O(SiO_4)(Si_2O_7)(OH)$	$(AL,Mg)_8(Si_4O_{10})_3(OH)_{10}12H_2O$	Fe_3O_4	$Ca_2Al(AlSi_3O10)(OH)_2$	$NaAlSi_3O_8$	TiO_2	Fe_2O_3	FeS_2
SQ1701	9.4	54.5	3.9	19.0	6.4	3.3	2.3	1.3	-	-	-	-	-
SQ1702	3.1	-	2.7	11.1	8.0	3.7	1.8	1.3	9.2	58.4	0.7	-	-
SQ1703	9.3	55.5	4.3	14.5	9.8	1.0	3.7	1.3	-	-	-	0.8	0.0
SQ1704	11.9	55.7	1.9	19.4	3.7	3.6	-	1.2	-	-	-	2.7	0.2

APPENDIX C – Photos and Samples Descriptions

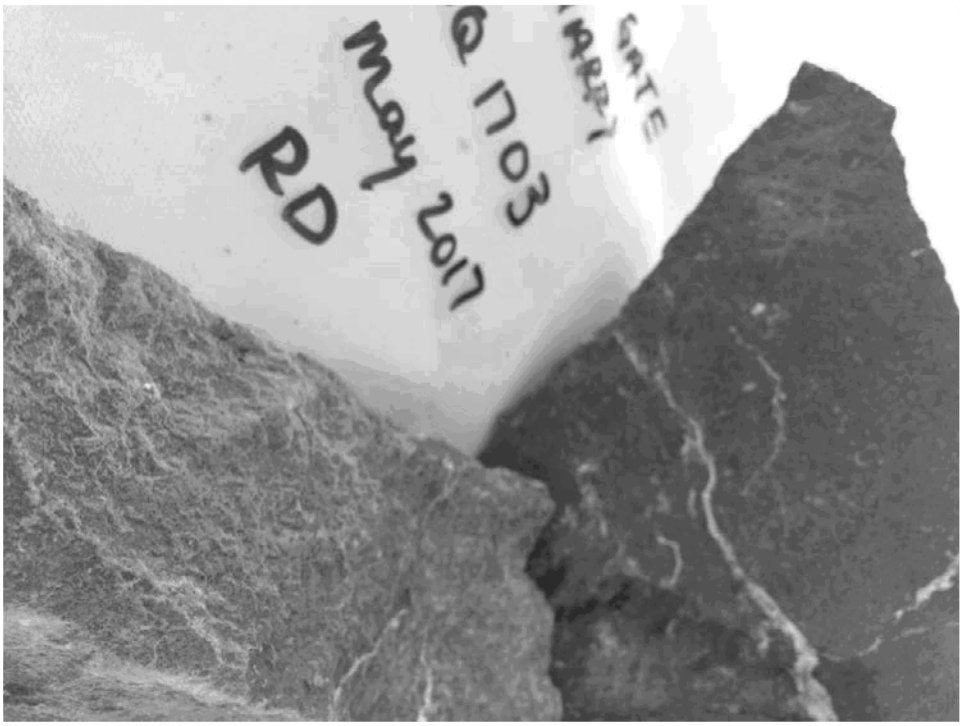




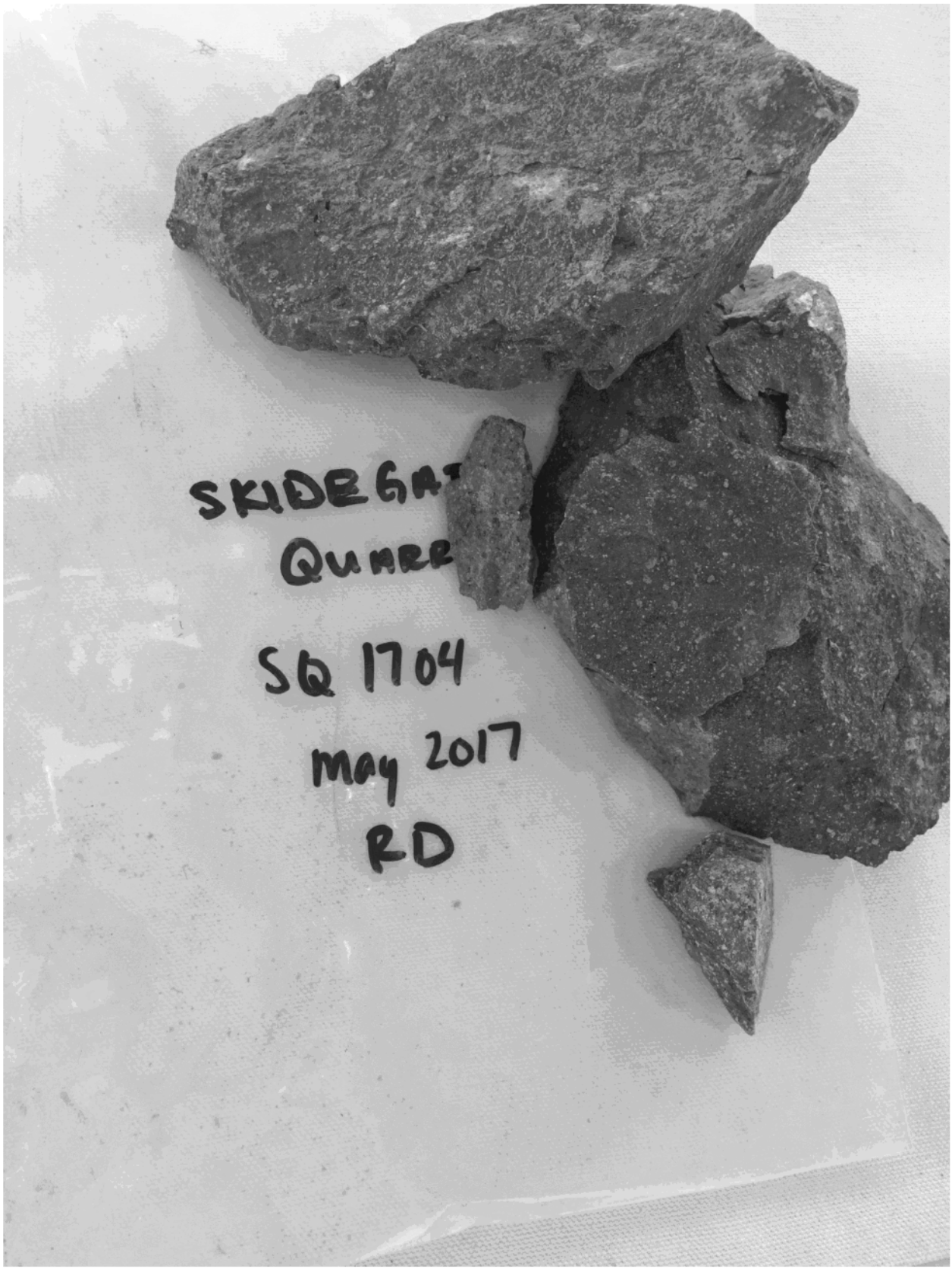


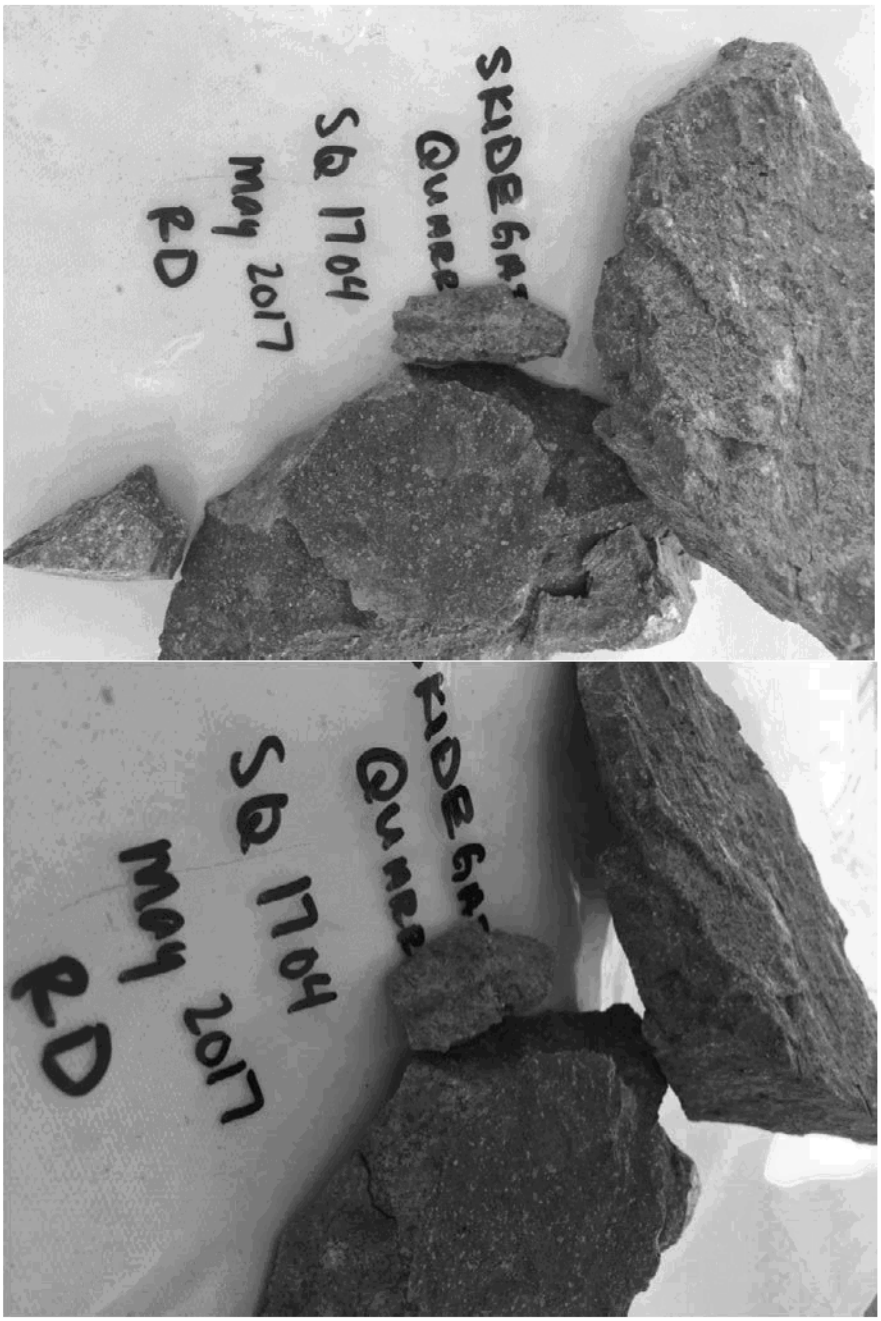
SQ1702 Description: green-grey andesite with small visible sulphides present (<1% by weight) with altered epidote. Calcite, primarily on joint faces was present. Slightly magnetic.


SKIDEGATE
QUARRY
SQ 1703
May 2017
RD



SQ1703 Description: green-grey andesite with trace sulphides, red hematite is present throughout matrix. Calcite vein is present throughout the sample.


SKIDEGA
QUARR
SQ 1704
May 2017
RD



SQ1704 Description: Highly weathered grey andesite off of the highest unblasted outcrop. Pyrite plucking is evident on surface, coarser grained, some iron staining present.