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REPORT ON EXPLORATION ACTIVITIES

APRIL 2017 – AUGUST 2019

MONCRIEFF PROJECT

GEOGRAPHIC TOWNSHIP OF MONCRIEFF
SUDBURY MINING DIVISION
DISTRICT OF SUDBURY
PROVINCE OF ONTARIO

D.S. DORLAND LIMTED
BRYAN DORLAND

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Greener North Inc. has retained the services of D.S. Dorland Limited to locate and investigate potential railway ballast quarry sites near the town of Cartier, Ontario. One particular area of interest has been located. Mining claims covering the potential license areas have been staked to eliminate any future disputes with potential Mining Rights holders at the Licensing stage. To date, a limited exploration program has been carried out to determine the feasibility of a Category 4 - Class "A" quarry under the Aggregate Resources Act and the suitability of the rock for railway ballast material. Exploration activities undertaken by D.S. Dorland Limited staff between April 2017 and August 2019 form the basis of this report.

1.0 PROJECT INFORMATION

1.1 LOCATION AND ACCESS

The Moncrieff Project is located in the annulled Geographic Township of Moncrieff in the District of Sudbury (Sudbury Mining Division) in the Province of Ontario. 1:50 000 scale NTS map sheet 041I43 encompasses the entirety of the project. The property is located in a remote area approximately 56 kilometres north west of the City of Greater Sudbury downtown core and approximately 7 kilometres north of the Town of Cartier. Travel time to the property is approximately 1 hour from the Sudbury area depending on road conditions.

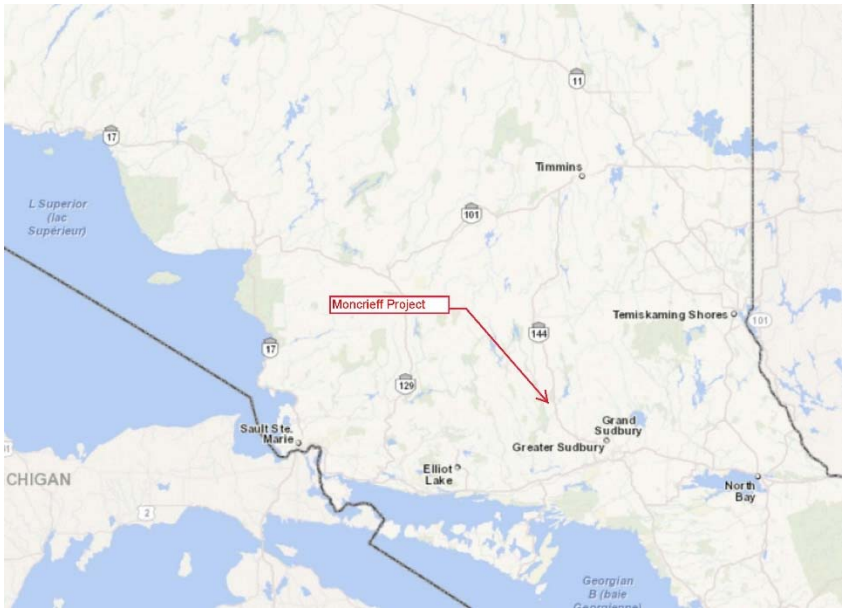


Figure 1 – Project Location

Access to the subject claims is excellent. The project can be accessed by truck by travelling north from Sudbury along Provincial Highway 144. A network of forest access roads currently provides seasonal access by truck to within 400 metres of the southerly property boundary. A former logging road, now used primarily by ATV's, crosses the property and provides good access to all parts of the claim group.

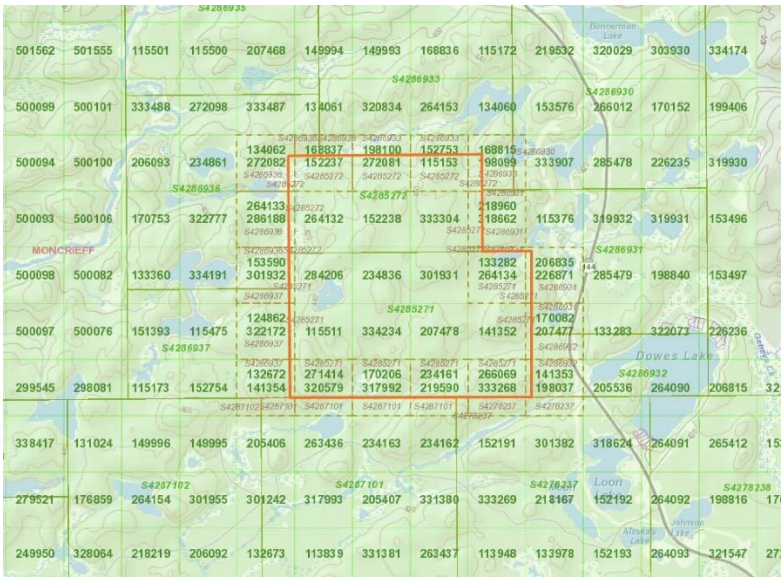


Figure 2 – Claim Map

If a License is obtained, it may be feasible to construct a new road from Highway 144 to access the potential quarry areas given the close proximity of the easterly boundary to the Highway.

1.2 TOPOGRAPHY AND VEGETATION

The Moncrieff Project is located in the boreal forest of northern Ontario in the Canadian shield. Topography generally consist of rugged and rolling bedrock hills with little to no overburden interlaced with lowland swamps and lakes as well as valleys filled with glacial debris. The average elevation in and around the project area is approximately 450 metres and relief about 30 metres.

Fault systems are commonly expressed by prominent topographic lineaments and scarps. The project area lies within the Great Lakes drainage basin and is subsequently drained south by the Spanish River and its tributaries.

The Project area has likely seen two generations of logging campaigns. Timber generally consists of stands of red, jack and white pine, the result of re-forestation, with some old growth white pine interlaced with stands of white birch, poplar, spruce and black spruce in the low lying, poorly drained areas.

1.3 TENURE DETAILS

The Moncrieff Project consists of 28 unpatented 1-unit mining claims with a total area of approximately 362 hectares. The property was acquired by ground staking in July and August 2017. The two legacy claims (4285271 and 4285272) were subsequently converted to grid cell and boundary claims with the advent of the Mining Act Modernization Program.

The claims are registered in the name of Greener North Inc and require $7,600 of annual assessment work to keep in good standing. See Table 1 for specific claim numbers and details.

2.0 PREVIOUS WORK

Based on publicly available sources of information, limited historic exploration activity has been carried on the ground covered by the Moncrieff Project and nothing specifically related to industrial minerals.

Below is a summary of previous assessment work or other work carried out over the Moncrieff Project currently on file at the Geoscience Assessment Office and AFRI database.

1981 – Ontario Geological Survey (Card, K.D. and Innes, D.G.)– Report 206 and accompanying maps (see map 2435)
1991 (published in 2003) - Ontario Geological Survey – Airborne Total Intensity Magnetic Survey and Electromagnetic Survey (Geophysical Data Set 1017) (see map 81541)
2019 – Ontario Geological Survey – Ramsey – Algoma Airborne Magnetic Gradiometer and Gamma-Ray Spectrometer Survey (Geophysical Data Set 1086a and 1086b) (see maps 82961, 82976 and 82991)

Table 1 – Mining Claim details

PROJECT: MONCRIEFF

CLAIM DETAILS

CLAIM No.	HOLDER	UNITS	AREA (ha)	EMCUMBERED	WORK REQD.	DUE DATE	WORK APPLIED	RESERVE
115511	Greener North Inc.	1	22.12	no	$400.00	August 22, 2019	$0.00	$0.00
115153	Greener North Inc.	1	22.12	yes	$200.00	August 22, 2019	$0.00	$0.00
124862	Greener North Inc.	1	22.12	yes	$200.00	August 22, 2019	$0.00	$0.00
141352	Greener North Inc.	1	22.12	no	$400.00	August 22, 2019	$0.00	$0.00
141353	Greener North Inc.	1	22.12	yes	$200.00	August 22, 2019	$0.00	$0.00
141354	Greener North Inc.	1	22.12	yes	$200.00	August 22, 2019	$0.00	$0.00
152237	Greener North Inc.	1	22.12	yes	$200.00	August 22, 2019	$0.00	$0.00
152238	Greener North Inc.	1	22.12	no	$400.00	August 22, 2019	$0.00	$0.00
168815	Greener North Inc.	1	22.12	yes	$200.00	August 22, 2019	$0.00	$0.00
170206	Greener North Inc.	1	22.12	yes	$200.00	August 22, 2019	$0.00	$0.00
207477	Greener North Inc.	1	22.12	yes	$200.00	August 22, 2019	$0.00	$0.00
207478	Greener North Inc.	1	22.12	no	$400.00	August 22, 2019	$0.00	$0.00
219590	Greener North Inc.	1	22.12	yes	$200.00	August 22, 2019	$0.00	$0.00
226871	Greener North Inc.	1	22.12	yes	$200.00	August 22, 2019	$0.00	$0.00
234836	Greener North Inc.	1	22.12	no	$400.00	August 22, 2019	$0.00	$0.00
264132	Greener North Inc.	1	22.12	no	$400.00	August 22, 2019	$0.00	$0.00
264133	Greener North Inc.	1	22.12	yes	$200.00	August 22, 2019	$0.00	$0.00
264134	Greener North Inc.	1	22.12	yes	$200.00	August 22, 2019	$0.00	$0.00
266069	Greener North Inc.	1	22.12	yes	$200.00	August 22, 2019	$0.00	$0.00
272081	Greener North Inc.	1	22.12	yes	$200.00	August 22, 2019	$0.00	$0.00
272082	Greener North Inc.	1	22.12	yes	$200.00	August 22, 2019	$0.00	$0.00
284206	Greener North Inc.	1	22.12	no	$400.00	August 22, 2019	$0.00	$0.00
301931	Greener North Inc.	1	22.12	no	$400.00	August 22, 2019	$0.00	$0.00
301932	Greener North Inc.	1	22.12	yes	$200.00	August 22, 2019	$0.00	$0.00
318662	Greener North Inc.	1	22.12	yes	$200.00	August 22, 2019	$0.00	$0.00
320579	Greener North Inc.	1	22.12	yes	$200.00	August 22, 2019	$0.00	$0.00
333304	Greener North Inc.	1	22.12	no	$400.00	August 22, 2019	$0.00	$0.00
334234	Greener North Inc.	1	22.12	no	$400.00	August 22, 2019	$0.00	$0.00
TOTAL		28	619.36		$7,600.00		$0.00	$0.00

3.0 GEOLOGY

3.1 REGIONAL GEOLOGY

The Moncrieff project is located in the southern part of the Superior Province of the Canadian shield north of the main contact between the Early Precambrian rocks of the Superior Province and the Middle Precambrian rocks of the Southern Province (Card/Innes, 1981).

The Benny Greenstone Belt, a preserved remnant of a formerly much larger supracrustal sequence of metavolcanics and metasediments, is located approximately 2 kilometres north of the claim group. The Belt strikes east west and dips strongly to the south with an average width of approximately 2 km, a maximum width of approximately 4.8 km and is over 38 km long.

The rocks of the Belt and surrounding area record a series of igneous, intrusive, deformational and metamorphic events ranging in age from Early to Late Precambrian. After deposition of the Early Precambrian metavolcanics and metasediments, probably on a basement of older sialic rocks, there was deformation, regional metamorphism and emplacement of granitic plutons during the Kenoran Orogeny some 2500 million years or so ago (Stockwell et al., 1970). This was followed, in the latter part of the Early Precambrian and the early part of the Middle Precambrian, by a period of tensional tectonics with emplacement of mafic dike swarms, faulting and foundering of Early Precambrian crustal blocks and deposition of Huronian clastic sedimentary rocks in a series of shallow epicratonic basins (Card/Innes, 1981).

The Moncrieff Project is also located approximately 20 kilometres north west of the northerly contact of the Sudbury Igneous Complex, a 1.8 billion year old Paleoproterozoic impact crater.

3.2 PROPERTY GEOLOGY

The Moncrieff project covers a portion of the Cartier pluton, an early Pre Cambrian intrusion of felsic intrusive and metamorphic rocks. The primary rock type found on the property consists of massive felsic intrusive rocks being fine to coarse grained quartz monzonite (unit 7 – Fig. 3) which have intruded the older foliated, felsic, plutonic and migmatitic rocks (unit 6 – Fig.3). Both units of felsic intrusive and metamorphic rocks have been intruded by younger mafic intrusive dikes and sills.

3.3 EXPLORATION TARGETS

The primary exploration target for the Moncrieff project is the mafic intrusive dikes and sills, primarily the larger Nipising Diabase type (unit 14 – Fig. 3). The Nipissing Diabase intrusions comprise pyroxene gabbro, hornblende metagabbro, granophyric metagabbro and granophyre. These units are generally a medium grained, dark grey, green to black and brown weathering rock composed of proportions of plagioclase, amphiboles and pyroxene with minor amounts of quartz, feldspar, epidote, biotite and or ilmenite-magnetite (Card/Innes, 1981).

The chemical and physical properties of this mafic intrusive unit make it an ideal candidate for railway ballast. Given the close proximity of the project to the Canadian Pacific Railway (CPR) depot at Cartier, a

major railway depot along the transcontinental main line, the Moncrieff Project could produce several quarries of good quality ballast material that could be economically extracted.

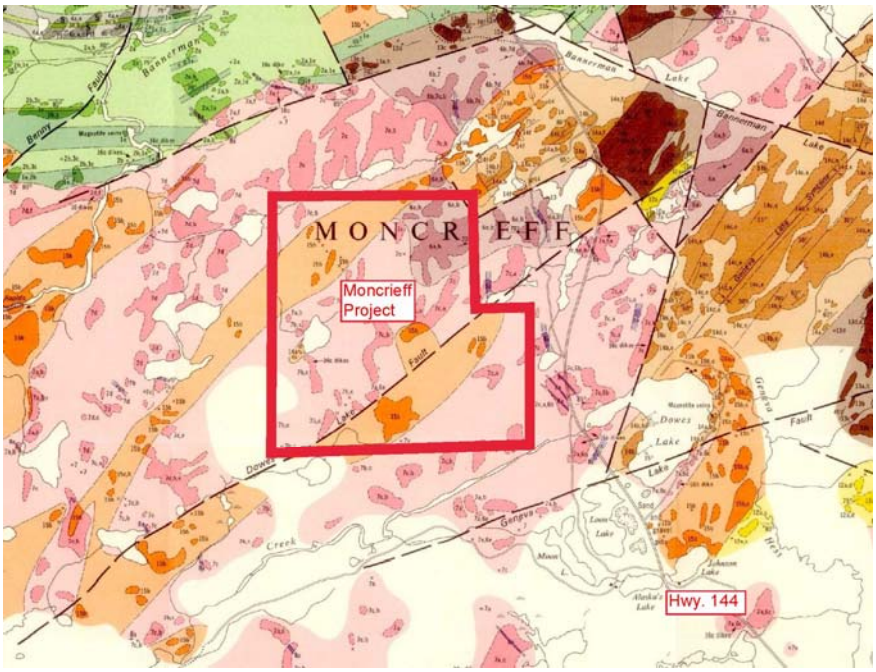


Figure 3 – Local Geology

4.0 ADJACENT PROPERTIES

Battery Mineral Resources has recently acquired an extensive land package covering the rocks of the Benny Greenstone Belt and of the southern Province which surround the subject claims.

5.0 CURRENT EXPLORATION ACTIVITES COVERED BY REPORT

5.1 DETAILS

Exploration activities carried out between April 2017 and August 2019 form the basis of this report. These activities include research and compilation of all previous exploration activities carried out on or in the immediate project area, prospecting and rock sampling. Appendix 2 provides a detailed breakdown of the work performed and associated costs.

Research and data compilation was carried out in order to locate rock units with the potential for railway ballast quarries near the CPR depot at Cartier and to generate targets to focus the preliminary field activities. All currently available geological maps and reports, aerial photography and topo maps, geophysical surveys and assessment files were reviewed in detail.

Once a prospective area was located, the ground was staked and a total of 7 days was spent in the field. Fieldwork included reconnaissance of road access and bedrock geology along roads, trail maintenance, general prospecting and bedrock sampling. The majority of the work program was focussed on the

Nipissing Diabase intrusions which cross the claim group. Appendix 1 illustrates the location of areas covered by the current fieldwork and rock sample locations.

Rock samples were taken at select locations for review with the client. A large grab sample (+/- 300 lbs as required for ballast test) was taken from an outcrop of Nipissing Diabase located in proximity of the most prospective quarry area. The sample was shipped to EXP's laboratory in Brampton to perform various test and chemical/petrographic analysis to determine if the rock would meet the Canadian Pacific Railway specifications for various grades of railway ballast. See Appendix 3 for sample details.

5.2 RESULTS

The exploration program to date has outlined two potential railway ballast quarry areas that may be extracted by a Category 4 - Class "A" quarry under the Aggregate Resources Act.

The subsequent physical, geochemical and petrographic analysis of the large, representative Nipissing Diabase grab sample would indicate that the mafic intrusions located on the Moncrieff Project are suitable for all classes of railway ballast as defined by the Canadian Pacific Railway Ballast specifications – January 1, 1984 revision (current). See Appendix 4 for analytical results and report by EXP.

6.0 RECOMMENDATIONS

It is recommended that detailed geological mapping be carried out over the prospective quarry locations to refine potential extraction limits and several drill holes be put down to confirm continuity of the potential ballast material at depth.

In addition, it is recommended that an Archeological Study and Natural Environment Level 1 Study be completed to determine if any cultural or environmental factors may adversely affect any proposed quarry. These would also be required to submit as part of the Application under the Aggregate Resources Act.

Finally, a hydro geological assessment to determine the groundwater table elevations should be commissioned in order to aid in assessing and designing any future extraction plans.

7.0 REFERENCES

Card, K.D., & Innes, D.G., 1981: Geology of the Benny Area, District of Sudbury; Ontario Geological Survey Report 206, 117p Accompanied by Maps 2434 & 2435, scale 1:31 680 and 4 Charts

Canadian Pacific Railway, 1984: Specifications for Ballast, Revised January 1, 1984

8.0 CERTIFICATE

I, Bryan Dorland certify that:

I graduated with a Mining Engineering Technician diploma from Cambrian College in 2008.

I have held a valid Ontario Prospector's License since 2006 (License No. 1012035)(Client No. 411680)

I have been actively participating in the mining and exploration industry since 2006.

I personally supervised the work described in this report.

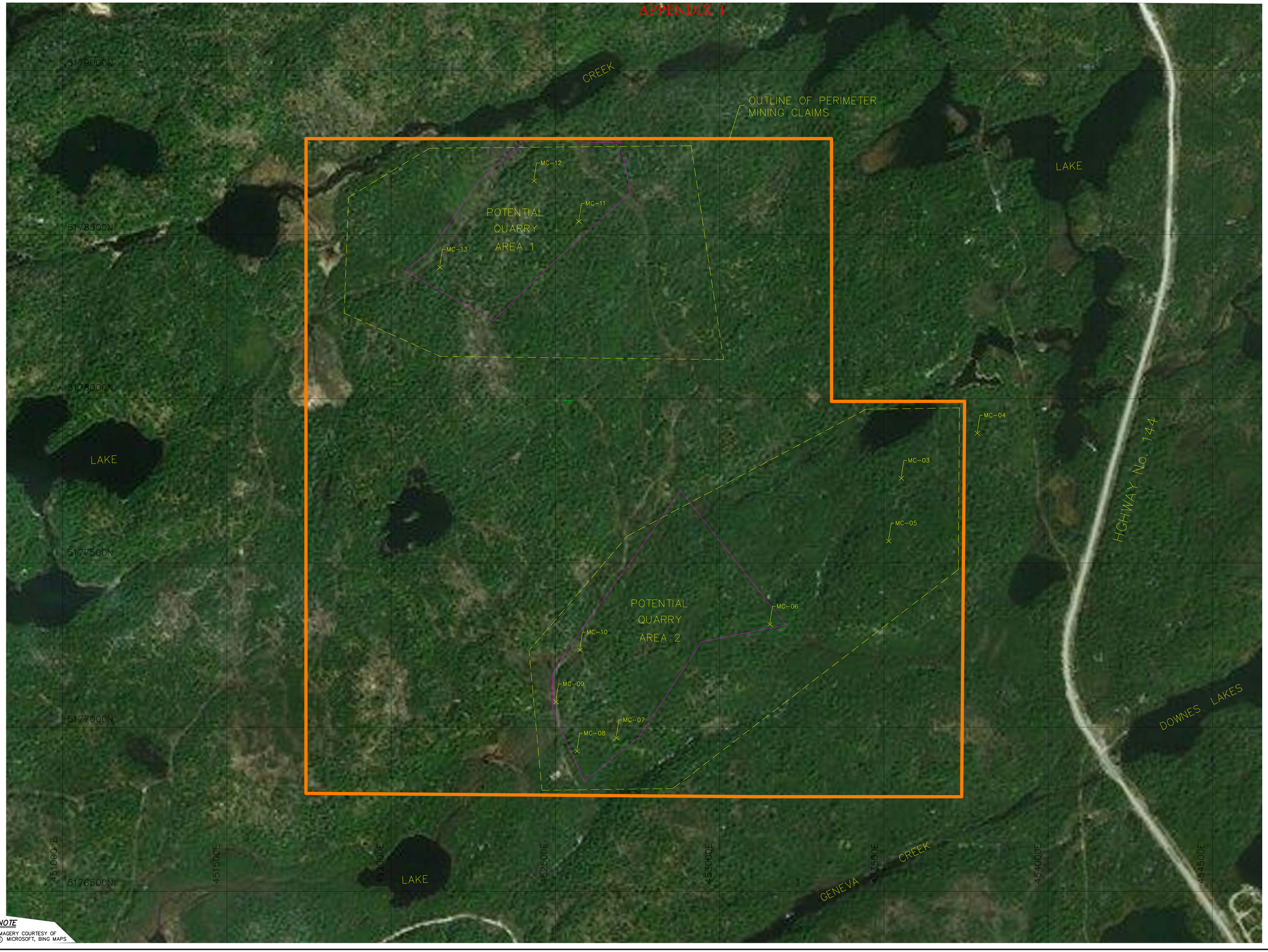
I have no interest the property described in this report.

Bryan Dorland

Dated August 21, 2019

Sudbury, Ontario

APPENDIX I



NOTE
IMAGERY COURTESY OF © MICROSOFT, BING MAPS

PLAN OF
MONCRIEFF PROJECT
2017 – 2019 WORK AREAS
GEOGRAPHIC TOWNSHIP OF
MONCRIEFF
SUDBURY MINING DIVISION
DISTRICT OF SUDBURY

SCALE 1:5000

0 50 100 200 METRES 30

LEGEND

DENOTES AREAS PROSPECTED

× DENOTES GRAB SAMPLE LOCATION

NOTE

SEE APPENDIX 2 IN ACCOMPANYING REPORT FOR EXPLORATION ACTIVITY DETAILS.

IN ADDITION TO THE PROSPECTED AREAS SHOWN HEREON, ALL ROADS WERE TRAVELED TO INSPECT ACCESS, OUTCROPS AND GEOLOGY.

SEE FIGURE 2 AND TABLE 1 IN THE ACCOMPANYING REPORT FOR FOR CLAIM NUMBERS

PROJECTION: UTM ZONE 17
DATUM: NAD83
UNITS: METRES

MONCRIEFF PROJECT

PREPARED BY : BCD	SCALE : 1:5000 METRIC
CHECKED : BCD	CAD FILE : 17690-GRID.dwg
DATE : AUGUST 21, 2019	P. SPACE TAB : 1 2017-2019 WORK AREA

ARCH D (24"X36") PAPER SIZE

APPENDIX 2

DAILY ACTIVITY LOG

PROJECT: MONCRIEFF

DATE	PERSONEL	TIME ($40/hour)	ACTIVITY	VEHICLES	MILEAGE (km) ($0.55/km)	ATV $100/day	SNOWMOBILE $100/day	UTV $150/day	CHAINSAW $30/day	ACCOMODATIONS Camper $50/day Trailer $75/day Others as incur.	FOOD $40/day	CHANNEL SAW $30/day	DGPS $100/day	MINI EXCAVATOR $500/day	ASSAYS (as incur.)	MISC. (field supplies, printing,etc)	ASSESSMENT VALUE
April 26, 2017	G.Roque	10	Recon/Prospecting	incl.							1						$440.00
April 26, 2017	S.McGraw	10	Recon/Prospecting	incl.							1						$440.00
April 26, 2017	B.Dorland	10	Recon/Prospecting	Truck	150			1	1		1					$ 10.00	$712.50
July 10, 2017	M.Boyle	10	Prospecting	Truck	150			1			1					$ 10.00	$682.50
September 5, 2017	M.Boyle	10	Prospecting/trail maintenance	Truck	150			1	1		1					$ 10.00	$712.50
September 6, 2017	M.Boyle	8	Prospecting	truck	150			1			1					$ 10.00	$602.50
December 6, 2017	B.Dorland	8	Prospecting	Truck	150			1			1					$ 10.00	$602.50
December 6, 2017	S.McGraw	8	Prospecting	incl.							1						$360.00
December 6, 2017	M.Boyle	8	Prospecting	incl.							1						$360.00
December 7, 2017	M.Boyle	8	sample prep. and shipping												$1,248.65	$ 428.53	$1,997.18
December 7, 2017	B.Dorland	8	data entry													$ 10.00	$330.00
August 16, 2019	B.Dorland	10	Prospecting	Truck	150	1					1					$ 10.00	$632.50
August 19, 2019	B.Dorland	10	Prospecting	Truck	150	1					1					$ 10.00	$632.50
August 20, 2019	B.Dorland	12	Data Entry/Report Prep													$ 15.00	$495.00
August 21, 2019	B.Dorland	12	Data Entry/Report Prep													$ 10.00	$490.00
TOTALS		142			1,050	2	0	5	2	$0.00	11				$1,248.65	$533.53	$9,489.68

APPENDIX 3

PROJECT: MONCRIEFF

ROCK SAMPLES

UTM ZONE 17, NAD83

SAMPLE No.	TYPE	POINT No.	NORTHING	EASTING	ELEVATION	DESCRIPTION/NOTES	SAMPLE DATE	ASSAYED	ASSAY DATE	NOTABLE ASSAYS	PHOTO
MC-03	Grab	107	5177758	453553	442	fine-med grained nipissing diabase	04.26.2017	NO			
MC-04	Grab	102	5177896	453784	434	fine-med grained nipissing diabase	04.26.2017	NO			
MC-05	Grab	111	5177567	453515	459	fine-med grained nipissing diabase	04.26.2017	NO			
MC-06	Grab	169	5177313	453153	440	fine-med grained nipissing diabase	07.10.2017	NO			
MC-07	Grab	155	5176968	452686	431	fine grained mafic intrusive, nip diabase?	07.10.2017	NO			
MC-08	Grab	141	5176927	452566	422	fine-med grained nipissing diabase	07.10.2017	NO			
MC-09	Grab	162	5177077	452502	415	fine-med grained nipissing diabase	09.05.2017	NO			
MC-10	Grab	163	5177235	452575	434	fine-med grained nipissing diabase, some Py	09.05.2017	NO			
MC-11	Grab	326	5178540	452572	458	fine-med grained nipissing diabase	12.06.2017	yes	January 2018	See EXP report	
MC-12	Grab	409	5178663	452435	443	med grained nipissing diabase	08.19.2019	NO			
MC-13	Grab	390	5178400	452148	418	med grained nipissing diabase	08.19.2019	yes			

exp Services Inc.
1595 Clark Boulevard
Brampton, Ontario, L6T 4V1
Tel: (905) 793-9800
Fax: (905) 793-0641
www.exp.com

APPENDIX 4

Potential Rail Ballast

Project Number: BRM-00501023-A0 **Project Name:** D.S. Dorland

Laboratory Test & No.	Test Results	Specifications for Ballast Track Classification					Meets Specification
		Primary CWR	Main Line Jointed	Secondary Main Line	Branch Line		
					Important	Minor	
Specific Gravity Absorption, ASTM C127							
Bulk Specific Gravity (SSD)	2.947						
Bulk Specific Gravity	2.936	Minimum:					
		2.6	2.60	2.60	2.60	2.60	√
Apparent Specific Gravity	2.938						
Absorption (%)	0.37	Maximum					
		0.5	0.75	1	1	1	√
Los Angeles Abrasion ASTM C535 (% wear)	8.6	<45					√
Magnesium Soundness ASTM C88 (% Loss)	0.8	Maximum					√
		1	1.5	3	3	3	
Fractured Particles Appendix A (%)	100	Minimum 60 - 100					√
PN CP Rail, Specification for Ballast, Montreal, Revised January 1, 1994	110	As per Appendix A					
Mill Abrasion	-	Not tested					
Abrasion Number	-	Not tested					

February 7, 2018

Testing Laboratory Representative Signature
Diane Henry

Date

LOS ANGELES ABRASION TEST

Description of Sample: Ballast
Sample No.: 17-699 (289309)
Project Name: D.S.Dorland
Project No.: BRM-00501023-A
Date Received: Dec 21, 2017
Sampled By: Client
Date Tested: January 9, 2018
Tested By: SR

Tested in Accordance with ASTM C-535

Sieve Size (Square Openings)		Mass (g)	Weight of Indicated Sizes (g) Grading		
Passing, mm	Retained on, mm		(1)	2	3
75	63	2454	2500±50		
63	50	2509	2500±50		
50	37.5	5046	5000±50	5000±50	
37.5	25			5000±25	5000±25
25	19.0				5000±25
Total		10009	10 000±100	10 000±75	10 000±50
Number of Spheres			(12)	12	12

WEIGHT RETAINED ON A 1.8 mm SIEVE (NO. 12) AFTER TEST: 9145 g

$$\% \text{ WEAR} = \frac{\text{Original Weight - Final Weight}}{\text{Original Weight}} \times 100\ \%$$

% WEAR = 8.6

Testing Laboratory Representative Signature
Ammanuel Yousif, C.E.T.

January 9, 2018
Date

exp Services Inc.
1595 Clark Boulevard
Brampton, Ontario, L6T 4V1
Tel: (905) 793-9800
Fax: (905) 793-0641
www.exp.com

Soundness Test of Aggregates

Description of Sample: Ballast
Project Name: D.S.Dorland
Date Tested: January 8, 2018
Project Number: BRM-00501023-A0
Sample Number: 17-699 (289309)
Tested by: SR

ASTM C88 $MgSO_4$ Temp: 21.0 +/- 1.0 °C Specific Gravity: 1.295- 1.308

SIEVE SIZE		GRADING OF ORIGINAL SAMPLE (%)	MASS OF TEST FRACTIONS BEFORE TEST (g)	PERCENTAGE PASSING FINER SIEVE AFTER TEST (ACTUAL % LOSS)	WEIGHTED AVERAGE (% LOSS)
PASSING	RETAINED				
SOUNDNESS OF FINE AGGREGATE					
4.75 mm	2.36 mm		100		
2.36 mm	1.18 mm		100		
1.18 mm	600 µm		100		
600 µm	300 µm		100		
Minus 300 µm					
TOTAL		100			
SOUNDNESS OF COARSE AGGREGATE					
6.3mm	37.5mm				
37.5mm	19mm	44.4	1514.7	0.4	0.2
19mm	13.2mm	50.0	1001.1	1.0	0.5
13.2mm	9.5mm	5.6	300.1	1.2	0.1
9.5mm	4.75mm				
TOTAL		100			0.8

Testing Laboratory Representative Signature
Ammanuel Yousif, C.E.T.

January 8, 2018
Date

exp Services Inc.
1595 Clark Boulevard
Brampton, Ontario, L6T 4V1
Tel: (905) 793-9800
Fax: (905) 793-0641
www.exp.com

Percent Fractured Particles

Project Name:	D.S.Dorland	Project No.:	BRM-00501023-A0
Description of Sample:	Ballast	Sample No.:	17-699 (289309)
Date Tested:	January 8, 2018	Tested By:	SR

Sieve Size	Total Mass (g)	Mass Unfractured (g)	Mass Fractured (g)	% FRACT x % RET.	Weighted Average Value (%)
37.5mm – 25mm	3001	0	3001	100 X 22.2	22.2
25mm – 19mm	1505	0	1505	100 X 22.2	22.2
19mm – 12.5mm	1002	0	1002	100 X 25.0	25.0
12.5mm – 9.5mm	511	0	511	100 X 25.0	25.0
9.5mm – 4.75mm	309	0	309	100 X 5.6	5.6
Total % Fractured					**100**

Testing Laboratory Representative Signature
Ammanuel Yousif, C.E.T.

January 8, 2018
Date

exp Services Inc.

SPECIFIC GRAVITY AND ABSORPTION OF COARSE AGGREGATE

Project No.: BRM-00501023-A0

Project Name : D.S.Dorland

Sample Description: Ballast

Sample No.: 17-699 (289309)

Date Tested : January 10, 2018

Bulk Specific Gravity (Saturated Surface Dry)	=	2.947
Bulk Specific Gravity	=	2.936
Apparent Specific Gravity	=	2.968
Absorption	=	0.37

Testing Laboratory Representative Signature
Ammanuel Yousif, C.E.T.

January 10, 2018
Date

Evaluating Ballast Stone for Petrographic Analysis

Source Name: D.S. Dorval

Sieve Fraction: P 19.0 mm to R 4.75 mm

Sample Number: 17-699 Ballast Stone

Project Number: BRM-00501023-A0

Petrographer: Ashley Meagher

Date Tested: January 19, 2018

Test Method: "CP Rail, Specification for Ballast, Montreal, Revised January 1, 1984."

Rock Types

The ballast stone sample is a fine grained diabase or more commonly named a "trap rock". Diabase is considered high strength and only a faint scratch may be possible when using a stainless-steel knife to determine hardness.

All identifications were made using standard visual and basic geological diagnostic techniques. No thin sections or X-ray analyses were utilized in these identifications. Hence, some descriptions should be regarded as tentative.

Mineralogy

Diabase is chemically equivalent to a Gabbro but finer grained. The main minerals observed in the sample include plagioclase feldspar and clinopyroxene augite. There are also accessory minerals of hornblende, biotite and olivine. To know the exact proportions and chemical composition thin sections must be acquired and evaluated.

Texture

The diabase examined is considered fine grained (less than 5 mm or not visible to the naked eye). The matrix material largely consists of plagioclase feldspar and augite. Each mineral exhibits different properties, for instance plagioclase feldspar has a blocky shape while augite has a prismatic shape. There is no specific orientation or foliation to these minerals. Accessory minerals such as olivine has a sugary texture, whereas hornblende is prismatic or bladed, and biotite is tabular. Partial melting of minerals is noted in the matrix material.

Structure and Mechanical Properties of

Diabase hardness is between a 5.0 and 6.0 on the Mohs hardness scale. Where 5.0 is the hardness of a stainless-steel knife. When crushed, the rock breaks around the individual grains, not through them in an irregular or conchoidal shape. Diabase is brittle and when crushed and breaks into sharp angular to sub angular fragments. Below is a chart of the major minerals within diabase and their mechanical properties.

Plagioclase Feldspar **General Forumla:** **$NaAlSi_3O_8$-$CaAl_2Si_2O_8$**	Fracture Planes: -
	Cleavage Planes: Cleavage difficult to determine, 1 at 90 degrees
	Hardness: 6.0-6.5
	Tenacity: Brittle
	Shape: Blocky
	Roundness: Sub-round
	Colour: White

Augite **General Formula:** **$(CA,Mg,Fe,Al)_2(Si,Al)_2O_6$**	Fracture Planes: Uneven to Conchoidal
	Cleavage Planes: 1,2 at 87 and 93 degrees
	Hardness: 5.5-6.0
	Tenacity: Brittle
	Shape: Stubby prismatic crystals
	Roundness: Angular
	Colour: Black to brown

Chemical Properties:

Chemical weathering rims were noted around the diabase aggregate. According to the petrographic analysis results approximately 5.0 percent of the sample has partial to thin surface weathering. One or more faces on the fair Diabase aggregate have rust colored weathering rims.

Properties of Fines:

There was no fine aggregate provided to be examined for this analysis.

Test Results:

The standard petrographic quality is measured through the calculation of a Petrographic Number (PN), which is determined by using a set of multipliers for the various quality classifications of each rock type. A rock type that is considered "Good", "Fair", "Poor", or "Deleterious" have multipliers of "1", "3", "6" and "10" respectively. The accompanying table provides a detailed listing of the rock types that were classified as "Good", and "Fair".

Diabase	**GOOD (hard/strong) multiplier "1"** (i) mainly high strength (ii) generally, cannot be scratched
	FAIR (brittle/medium strength) multiplier "3" (i) Mainly medium to high strength (ii) Generally, cannot be scratched (iii) Brittle edges and the corners can be plucked (iv) Minor to medium to low strength zones that can be plucked with ease (v) have partial to thin surface weathering

A petrographic number was calculated of for each individual size fraction. Below is a table with the findings.

Ballast Stone	% Retained on Sieve	Sieve Examined	Petrographic # (PN)
P 26.5 mm R 19.0 mm	5.3%	not examined	-
P 19.0 mm R 13.2 mm	22.3%	examined	109.6
P 13.2 mm R 9.5 mm	31.6%	examined	114.3
P 9.5 mm R 4.75 mm	40.8%	examined	106.8

An average weighted PN was also calculated according to the percent retained on each sieve.

Average Weighted PN
110

The petrographic number calculated is considered "Good" in its physical and mechanical quality.

Special Tests Required:

To determine specific mineralogy thin sections will be required.

Summary:

The ballast stone sample is a fine-grained diabase or more commonly named a "trap rock". The main mineral assemblages are plagioclase feldspar and clinopyroxene augite with secondary minerals of hornblende, biotite, and olivine. The sample is brittle, and angular to sub angular when crushed. The weighted average petrographic number is 110. This is considered "Good" in petrographic terms for its physical and mechanical quality.

Approved By:

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