SUPPLEMENTARY REPORT
TO
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT
ON
BEAUFORT REGION QUARRY ROCK STUDY

Golder Associates

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Golder Associates
CONSULTING GEOTECHNICAL AND MINING ENGINEERS

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TO
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT
ON
BEAUFORT REGION QUARRY ROCK STUDY

DISTRIBUTION:

25 copies - Department of Indian Affairs and Northern Development
Hull, Quebec

1 copy - Golder Associates
Vancouver, B.C.

March, 1988

862-1806

1.0 INTRODUCTION

This supplementary report presents the results and interpretations of additional work carried out by Golder Associates (Golder) in regard to the evaluation of a number of potential quarry rock sources in the western Arctic. Golder was awarded D.S.S. Contract 38ST.A7134-6-0016 early in September, 1986 to carry out the geotechnical characterization of the rock mass at six specified sites in the Northwest Territories and Yukon Territory close to the Mackenzie Delta. During the study, preliminary evaluation was also made of a number of additional sites, and Golder was subsequently requested to present a proposal to the Department of Indian Affairs and Northern Development (DIAND) for supplementary work. The original contract was amended in June, 1987 to include an appraisal of two existing quarry sites near Inuvik, N.W.T., in order to be able to fully evaluate them in comparison with the original sites; the two quarries are known as the DPW Quarry and the Campbell Pit.

The sites were visited by Golder in October, 1987 for back-up reconnaissance mapping and to collect sufficient samples for the complete suite of laboratory testing required in the original contract. Further photographs of the quarries were also taken. The samples were shipped to Vancouver for testing in Golder's laboratory.

2.0 SCOPE OF REPORT

This report contains the results of all laboratory tests carried out to date and summarizes them in table form. The tables are updated versions of those presented in the main report, dated August, 1987, which should be read in conjunction with this supplementary document. The laboratory test result sheets which have been amended are captioned

Tables 6, 7, 8, 9 and 10. Summary sheets are amended as Tables 11 and 14.

The engineering evaluations presented in the original report are amended by inclusion of a revision sheet; and the recommendations for future work are replaced by a new section 8 contained herein. The numbering of the tables and aforementioned section is compatible with the original report.

3.0 DATA COLLECTION

The two sites were visited in October, 1987. Both quarries had experienced considerable development in the previous 12 months which meant that a revised appraisal of the exposed rock mass could be made. Over 40 kg of sample were obtained from each quarry site in the form of large rock blocks and crushed stone from stockpiles. In Golder's opinion, the degree of weathering of these samples was similar to that for the felsenmeer samples from the original six sites; penetrative weathering was limited to a few miltimetres from the block margins in all cases, and all crushed rock tests were carried out on fresh rock.

3.1 DPW Quarry

Between October, 1986 and October, 1987 the DPW Quarry had been deepened by about 10 m and several stockpiles of crushed rock generated. The rock mass exposed showed that the thickly bedded sequence shown in Photograph 16 of the original report dies out with depth and, although the rock mass description remains unchanged, the potential volume of select stone of armour or rip rap size is limited. The highly weathered zones persist with depth and render this quarry a limited prospect.

3.2 Campbell Pit

By contrast with the DPW Quarry, the exploitation of the Campbell Pit has confirmed the quality of good grades of rock as the quarry has been expanded. This prospect is considered to present excellent potential, especially if limited quantities of larger grades are required. It may be considered in conjunction with the Gull Creek Dolomite if a larger quantity is required from sources accessible locally from Inuvik.

4.0 PRESENTATION OF RESULTS

The results of the supplementary study are included in the supporting documents to this report and summarized in Tables 6, 7, 8, 9, 10, 11 and 14. The table numbers are identical to those given in the original report, and these tables should be considered as revisions of the earlier versions. Tables 6 through 11 were contained in Section 5 of the main report, while Table 14 was included in Section 6.2. Section 8.0, Future Work Programs, is replaced in its entirety by Section 8.0 of this report. The revised section is presented with its original numbering; all other sections remain unchanged except as noted in the revision letter appended to the earlier report.

8.0 FUTURE WORK PROGRAMS

During the Beaufort Region Quarry Rock study, a total of nine sites were evaluated. Of these sites, the most technically feasible for the production of large quantities of armour stone and riprap appear to be sites 1 (Mt. Fitton), 5 (Gull Creek Dolomite) and X2 (Campbell Pit). Further evaluation of Site X2 (DPW Quarry) in October, 1987 indicates that there is unlikely to be an acceptable quantity of the better grades of rock. Further work at this site is not considered justified at this time.

Additional work will be required at each of the sites showing the greatest potential; Mt. Fitton on the west (Yukon Territory) side of the Delta, and the Gull Creek Dolomite prospect and Campbell Pit on the east (N.W.T.) side before the most appropriate source(s) of the various select stone grades can be established. The studies should initially be aimed at bringing some or all of these prospects to a level where the general nature and extent of the resources have been established, and sufficient basic engineering has been performed to support overall feasibility studies, including cost estimates. This information would then form the basis for the selection of the appropriate site(s) of operations when stone requirements become apparent.

The following discussions are intended to indicate the further work programs considered necessary to establish the required data bases to support feasibility-level studies on the three recommended prospects.

8.1 Mt. Fitton (Site 1)

A detailed investigation program would be required to support a feasibility-level study on the Mt. Fitton prospect. Exposure of out-crop at the site is limited, and in consequence, a drilling program would be required to establish the full extent of the granite stock, and to confirm that suitable quantities of the larger stone grades could be successfully quarried. At least four coreholes, each up to 50 m in length, would be required. The suggested locations for the proposed coreholes are presented on Figures 1-2, in Section 6. Ideally, these holes should be drilled at N-size or greater. However, in view of the isolated location, a small, helicopter-borne hydraulic drill may have to be used, drilling at A- or B-size.

The drill core logging data would be supplemented by more detailed mapping of any other available exposure identified during summer months, and laboratory testing of samples from depth.

A test blast should be attempted, but again, because of the location, it may have to be restricted in size, since it could be difficult to justify the transportation of heavy drilling or excavating equipment to the site unless a critical industry need is identified.

A detailed investigation of the haul route to the coast will be essential in order to find the most suitable alignment, particularly in the sensitive permafrost areas of the coastal lowlands. Several major creek/river crossings would be required, particularly if the product is to be taken to King Point. Because of the distance to the coast, the study would probably involve a detailed helicopter survey, with extensive "ground-truthing". This would probably take several crew-weeks, but would be justified, since the haul road construction and transportation are likely to be major cost items if stone is to be quarried at this site.

8.2 Gull Creek Dolomite (Site 5)

With almost total exposure on all four sides and the top of the Gull Creek Dolomite outcrop, it is not considered necessary to drill to provide the data required to support a feasibility-level study. Rather, detailed mapping of the butte in summer should be sufficient to indicate any areas of structural disturbance, where the large stone sizes might not be obtained, and/or less durable rock might occur. This would be required for detailed quarry designs.

The structural mapping should also be used to confirm the joint orientations and spacing throughout the prospect. In this way, the approximate proportions of the respective product sizes could be estimated, and subsequently compared with actual results obtained in a test blast.

A test blast is recommended to confirm that suitable stone sizes can be obtained, particularly if there is a requirement for armour stone. This test should involve a sufficiently large volume of rock that the relative proportions of the various stone grades can be established.

Walk-over surveys will be required to establish actual alignments for the access road, and the road to the barge loading site. However, since there are no large streams or rivers along either routing, and the topography is relatively gentle, more detailed investigations are not envisaged.

At a feasibility level, investigations for the barge loading dock are likely to be relatively straightforward, since at the proposed site rock outcrop extends along the river bank for several kilometers. It should therefore be possible to establish a suitable location by field inspection, supported by depth soundings in the East Channel.

8.3 Campbell Pit (Site X2)

An outline for the development of the Campbell Pit ("Town Quarry Area") was presented in the EBA report dated September, 1976. This conceptual proposal involved the extension of the existing operation to the northwest on the opposite side of the ridge from the Mackenzie Highway. A two-phased approach was indicated, giving a total of approximately 2 million cubic metres of material.

Laboratory tests confirm the strength and durability of the stone from the present quarry and the next stage would involve an exploration program to confirm the extent of similar material to the northwest. This investigation should involve mapping of available exposures on the ridge, and the drilling of at least four core holes to confirm the nature of the material at depth. These holes should be extended at least to elevation 65 m, which approximately corresponds to the proposed quarry floor elevation.

A test blast should also be performed in the current quarry to confirm that the required stone sizes can be obtained on a production basis, and the proportions of the various grades developed.

Depending upon the quantity of stone required, studies might also eventually involve the upgrading of the available highway and barge loading facilities to obviate the need to run haul trucks through Inuvik.

TABLE 6

ROCK STRENGTH RESULTS

SITE NUMBER	UNIAXIAL COMPRESSIVE STRENGTH (MPa)		APPROXIMATE UNIAXIAL COMPRESSIVE STRENGTH* (MPa)			ROCK STRENGTH RANKING**
	Low	High	Low	Mean	High	
1	52.1	85.0	75	125	178	2
2	89.3	111.2	111	140	164	1
3	52.1	106.4	86	106	130	2
3C	85.9	87.0	99	105	110	2
4	87.1***		117	163	206	1
5	71.1	105.2	49	85	132	3
6	No cored specimens		40	72	106	3
X1	126.0	140.2	106	115	125	1
X2	110.4	146.8	130	134	137	1

NOTES:

* Approximate uniaxial compressive strength = 24 I_s (50), based on Point Load index.

** All rock material strengths are in the range of 'strong' to 'very strong'. Ranking is based on an interpretation of a small range of strengths.

*** Only one specimen could be cored for uniaxial testing.

TABLE 7

UNIT WEIGHT AND SPECIFIC GRAVITY

SITE NUMBER	ROCK TYPE	UNIT WEIGHT (kN/m^3)	SPECIFIC GRAVITY (Gs)	RANKING*
1	Porphyritic Granite	26.1	2.66	2
2	Quartzite	25.2	2.62	3
3	Quartz Sandstone	23.8	2.67	4
3C	Quartz Sandstone	22.5	2.65	5
4	Quartzite	25.0	2.66	3
5	Crystalline Dolomite	27.4	2.86	1
6	Biomicritic Limestone	26.1	2.70	2
X1	Biomicritic Limestone	26.9	2.74	2
X2	Biomicritic Limestone	26.8	2.73	2

* The ranking is a qualitative interpretation of the materials tested.

TABLE 8

LOS ANGELES ABRASION

SITE NUMBER	PHYSICAL DESCRIPTION OF AGGREGATE	LOS ANGELES ABRASION (% Loss)	ABRASION RANKING***
1	Very hard, angular, some equidimensional	27.7	1
2	Hard, angular	27.1	1
3	Hard, angular, some platy and prismatic	33.4	2
3C	Hard, subangular**	52.9	3*
4	Hard, angular some prismatic	26.8	1
5	Hard, angular to subangular	27.1	1
6	Moderately hard, angular, some platy	54.2	3*
X1	Hard, angular, some platy**	33.8	2
X2	Hard, angular, some platy**	29.6	2

* Unacceptable, based on maximum permissible loss of 45% for ASTM C535.

** ASTM C535 grading 2, all others grading 1.

*** Based on qualitative interpretation of laboratory testing.

TABLE 9

SODIUM SULPHATE SOUNDNESS
(5 Cycles)

SITE NUMBER	GRADING	SODIUM SULPHATE SOUNDNESS (% Loss)	SOUNDNESS RANKING
1	Coarse	0.94	1
2	Fine	2.98	2
3	Coarse	4.15	3
3C	Fine	27.28	4*
4	Coarse	0.86	1
5	Coarse	0.76	1
6	Coarse	0.86	1
X1	Coarse	0.26	1
X2	Coarse	0.18	1

* Unacceptable, greater than 5 per cent

TABLE 10

SLAKE DURABILITY INDEX

SITE NUMBER	ROCK TYPE	SLAKE DURABILITY INDEX (% retained) 1st Cycle	2nd Cycle	3 Cycle
1	Granite	98.8	98.3	97.8
2	Quartzite	99.4	99.1	98.9
3	Sandstone	98.8	98.4	97.9
3C	Sandstone	99.2	98.8	98.5
4	Quartzite	99.5	99.2	99.1
5	Dolomite	99.0	98.5	98.1
6	Limestone	99.2	98.9	98.6
X1	Limestone	99.6	99.4	99.2
X2	Limestone	99.6	99.3	99.0

All acceptable, extremely durable, better than 98 per cent after 2 cycles.

TABLE 11

SUMMARY OF LABORATORY TEST RESULTS

SITE AND ROCK TYPE	ROCK STRENGTH	UNIT WEIGHT	L.A. ABRASION	SULPHATE SOUNDNESS	SLAKE DURABILITY	PETROGRAPHY	OVERALL RANKING
Mt. Fitton Granite	2	2	1	1	1	1	1
Mt. Davies Gilbert Quartzite	1	3	1	2	1	1	1
Mt. Gifford Sandstone	2	4	2	3	1	1	2
Roche Moutonee Sandstone	2	5	3*	4*	1	2	4
Gull Creek Quartzite	1	3	1	1	1	1	1
Gull Creek Dolomite	3	1	1	1	1	1	1
Delta Outlier Limestone	3	2	3*	1	1	2	3
DPW Quarry Limestone	1	2	2	1	1	1	1
Campbell Pit Limestone	1	2	1	1	1	1	1

* Denotes unacceptable value

Numbers in table refer to laboratory test ranking in detailed Tables 6 to 10

TABLE 14

OVERALL COMPARATIVE RATING

		ABILITY TO PROVIDE PRODUCT					MATERIAL QUALITY			CONSTRAINTS				OVERALL RATING OF SITES
Site Number	LOCALITY	ARMOUR STONE*	RIP-RAP	BLAST ROCK	GENERAL FILL	CONCRETE AGGREGATE	MATERIAL STRENGTH	DURABILITY	BLASTABILITY	POTENTIAL QUANTITY	ACCESS	HYDROLOGY	WILDLIFE CONCERNS	
1	Mt. Fitton	4/4	4	4	4	3	3	4	4	4	2	4	2	4
2	Mt. Davies Gilbert	2/3	4	4	4	3	4	3	3	4	2	3	2	2
3	Mt. Gifford	3/2	3	4	4	3	3	2	3	3	2	3	2	2
3C	West Delta Roche Moutonee	3/1	3	4	4	3	3	1	3	1	3	2	3	1
4	Gull Creek Quartzite	4/3	4	4	4	3	4	4	3	2	3	3	2	3
5	Gull Creek Dolomite	4/4	4	4	4	3	3	4	4	4	3	3	2	4
6	Delta Outlier	1/1	2	3	4	3	3	1	3	3	3	1	3	1
X1	DEW Quarry	3/2	4	4	4	3	3	3	3	2	4	4	3	2
X2	Campbell Pit	3/3	4	4	4	3	3	3	3	3	4	4	3	3

NOTE: Significance Codes

1 = Unacceptable
2 = Poor
3 = Good
4 = Excellent

Comparative rating of prospects

* Significance code for armour stone also includes potential quantity, e.g. 3/1. Good prospect but unacceptable quantity of product.

SUPPORTING DOCUMENTS

Public Works Canada / Travaux publics Canada
Western Region / Région de l'Ouest

03 December 1987

Our File
6221-A3-14

Golder Associates
224 West 8th Avenue
Vancouver, B.C.
V5Y 1N5

Attention: Mr. Juan Benitez

Dear Sir:

Re: Mackenzie Highway, N.W.T.
Campbell Lake Rock Quarry

With reference to our telephone conversation of December 3, 1987, attached for your information are lab results on crushing samples taken during 1979 and 1980. This rock quarry is located on the east side of Campbell Lake.

The amount of soft material in the crushed product was considered to be insignificant and the material was considered to be a sound surfacing aggregate.

Yours truly,

C. Yurchak
Project Manager
Transportation
Architectural & Engineering Services
Public Works Canada
Western Region
(403) 420-3229

Attachment

of Campbell Lake is durable. However, Yurchack (personal communication) reports that material from this quarry has not performed adequately as a road surfacing stone. By interpretation, it may also perform poorly for riprap or armour stone."

Page 42, Last paragraph: Delete last sentence.

Page 43, Paragraph 1, Line 7: Change "The rock product ... testing" to, "Laboratory tests show the rock product to be durable and fairly resistant to weathering."

Page 47, Paragraph 2: Delete.

Page 42, Fourth page after Page 42, Rock Mass Description Sheet, Section entitled "Sample" should be updated to contain:

Location: Pit and stockpile
Size: 43.2 kg

Page 43, Fourth page after Page 43, Rock Mass Description Sheet; Section entitled "Sample" should be updated to contain:

Location: Pit and stockpile
Size: 47.2 kg

Yours very truly,

GOLDER ASSOCIATES
(WESTERN CANADA) LTD.

David F. Wood

D.F. Wood
Project Engineer

DFW/gg
862-1806

Government of Canada Gouvernement du Canada

MEMORANDUM **NOTE DE SERVICE**

TO / À: (1) Huculak (2) Thomson (4) NOTE TO FILE (3) Kimball

SECURITY - CLASSIFICATION - DE SÉCURITÉ

OUR FILE/NOTRE RÉFÉRENCE: 6221-A3-14

YOUR FILE/VOTRE RÉFÉRENCE

DATE: 1980-08-29

FROM / DE: Head, Geotechnical Services
Design & Construction

SUBJECT / OBJET: Campbell Lake Pit - Soft, Deleterious Mtl.

The following summarizes lab. tests in Edmonton on samples from the above pit taken during the course of the crushing contract.

DATE	% - #200 sieve (Spec: 12 to 18%)	Los Angeles Abrasion Test - % Loss (Allowable ≤ 35%)
79-11-14	13.3	24.2
79-11-21	3.6	24.1
80-03-12	3.0	25.2
80-03-18	3.8	23.8
80-03-25	9.3	24.4
80-04-03	3.6	24.8
80-04-16	6.8	22.7
	Ave. 6.2%	Ave. 24.1%

Subsequently two (2) samples were taken from the face of the completed stockpile by R. Thomson & E. Viddal to check on the deleterious mtl. On receipt of these samples in Edmonton (approximately 50 lbs.) ~~at~~ the soft particles retained on the #4 sieve were hand picked from the samples and weighed. These particles constituted only 0.13% and 0.58% of the total samples by weight.

Testing of the two samples produced the following data:

% - #200 sieve	Los Angeles Abrasion loss(%)
7.6%	19.0%
5.1%	22.7%
Ave. 6.35%	Ave. 20.8%

... 2

) Note To File
1980-08-29

It was considered that a large percent of soft particles sampled at the stockpile could have broken down to-#4 material during transport to Edmonton. However, a comparison of site sieve analyses with lab. analyses for the % passing #4 sieve reveal comparable values (average of 25.9% for 119 field tests vs average of 25.5% for 9 lab. tests).

Thus it can be concluded the amount deletrious material in the Campbell Lake stockpile is insignificant and the material is a sound surfacing aggregate.

R.D. Cook
Head, Geotechnical Services
Design & Construction
Western Region

NATURAL DENSITY TEST. SUBMERGED WAX METHOD

FIGURE

Project No.

JOB N° 862 1806 TITLE ______ Date ______

Bore Hole ______ Sample X-1 Depth ______ by ______

Volume of Wax

Wt. soil + wax ② = 166.1 gr

Wt. soil ① = 162.3 gr

Wt. wax = 3.8 gr

Vol. wax $\left(\frac{\text{Wt. wax}}{0.849}\right)$ = 4.48 cc

Volume of Soil + Wax

Wt. soil + wax ② = 166.1 gr

Wt. submerged ③ = 102.3 gr

Vol. soil + wax = 63.8 cc

Volume of Soil

Vol. soil + wax = 63.8 cc

Vol. wax = 4.48 cc

Vol. soil = 59.3 cc

W.C. Determination	
DISH N°	
Wt. wet soil + tare	
Wt. dry soil + tare	
Wt. tare	
Wt. water	
Wt. dry soil	
Water Content %	

Natural Density $\gamma_{nat.} = \frac{\text{Wt. soil}\ 162.3}{\text{Vol. soil}\ 59.3} =$ 2.74 g/cm^3

Dry Density $\gamma_d = \frac{\gamma_{wet}}{1 + \text{W.C.}} =$ ______ g/cm^3

Golder Associates

NATURAL DENSITY TEST - SUBMERGED WAX METHOD

FIGURE

Project No.

JOB N° 8621806 TITLE ______ Date ______

Bore Hole ______ Sample X-2 Depth ______ by ______

Volume of Wax

Wt. soil + wax ② = 210.4 gr

Wt. soil ① = 203.2 gr

Wt. wax = 7.2 gr

Vol. wax $\left(\frac{\text{Wt. wax}}{0.849}\right)$ = 8.48 cc

Volume of Soil + Wax

Wt. soil + wax ② = 210.4 gr

Wt. submerged ③ = 127.6 gr

Vol. soil + wax = 82.8 cc

Volume of Soil

Vol. soil + wax = 82.8 cc

Vol. wax = 8.48 cc

Vol. soil = 74.3 cc

W.C. Determination	
DISH N°	
Wt. wet soil + tare	
Wt. dry soil + tare	
Wt. tare	
Wt. water	
Wt. dry soil	
Water Content %	

Natural Density $\gamma_{nat.} = \frac{\text{Wt. soil } 203.2}{\text{Vol. soil } 74.3} =$ 2.73 g/cm³

Dry Density $\gamma_d = \frac{\gamma_{wet}}{1 + W.C.} =$ ______ g/cm³

Golder Associates

B.H. LEVELTON & ASSOCIATES LTD.

8805 OSLER STREET
VANCOUVER, B.C. CANADA V6P 4G1
(604) 266-1411 ■ TELEX 04-55581
FAX: (604) 266-0130

November 27, 1987

File: 187-598

Mr. W. Gilmer
c/o Golden Associates Ltd.
224 West 8th Avenue
Vancouver, B.C.
V5Y 1N5

Dear Sir:

Re: Sample X1 and X2
L.A. Abrasion, A STM C535, Grading 2

Testing has been completed on two samples, in accordance with A STM C535, Grading 2. Test results are given in the following table.

	PASSING mm	RETAINED ON mm	ORIGINAL MASS gms	FINAL MASS gms	LOSS gms	%
X1	50	37.5	4995			
	37.5	25.0	5000			
		TOTAL:	9995	6639.2	3355.8	33.6%
X2	50	37.5	5038.9			
	37.5	25.0	5008.5			
		TOTAL:	10,046.4	7094.0	2953.4	29.4%

If there are any questions related to this report, please direct them to my attention.

Yours very truly,

B.H. LEVELTON & ASSOCIATES LTD.

Bob Baturin

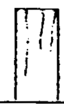
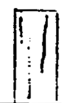
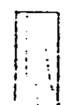
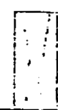
R.A. Baturin, P.Eng.

RAB*js

LABORATORY TEST RESULTS
UNIAXIAL COMPRESSION TEST

Project DSS Project Number 8621806

Date 02/11/87 Sheet 1 of 1 Technician M.O

Borehole No.	Sample No.	Depth	ϕ (cm)	L (cm)	L/ϕ	Wt. (g)	Gauge (MPa)	Factor	Breaking Stress (MPa)	Remarks
X 1	1		4.29	9.2		367.6	1140×0.0069 7.87	16.0	126.0	
"	2			9.9		394.6	1270× " 8.76	"	140.2	
X 2	1			9.9		378.0	1000× " 6.9	"	110.4	
"	2			10.0		377.9	1330× " 9.18	"	146.8	

FACTOR: Ram Area 230 cm^2

Sample Area $\frac{\pi}{4} \cdot 4.29^2 = 14.4\ cm^2$

$\therefore = 230/14.4 = 16.0$

LABORATORY TEST RESULTS
POINT LOAD TEST

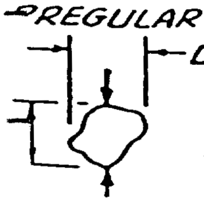
Project: DSS/QUARRIES Project Number: 8621806

Date: ______ Sheet ____ of ____ Technician: M.O

Borehole	Sample	Depth	~~Axial~~ Irregular TEST D (cm)	L (cm)	D/L	DIAMETRAL T D (cm)	L (cm)	D/L	G READING MPa	CALIB. FACTOR m^2	P MN	D^2 m^2	$I_s = \frac{P}{D^2}$ MPa	I_s50 MPa	(24) $\times I_s50$ MPa
										$\times 10^{-4}$					
X1			3.8	3.5	1.1				850×.0069 5.87	13.1	76.9	14.4	5.34	4.7	113
			4.6	3.7	1.2				1260× — 8.69		113.8	21.2	5.37	5.2	125
			3.4	2.1	1.6				670× — 4.62		60.5	11.6	5.22	4.4	106
2			2.6	3.5	0.74				870× — 6.00		78.6	6.76	11.6	7.0	168
			2.6	2.8	0.93				700× — 4.83		63.3	6.76	9.36	5.9	142
			3.0	4.0	0.75				1000× — 6.90		90.4	9.0	10.0	7.0	168
			* For Sample X2 $D/L < 1.0$												
			D×L can be better than D^2.												
X2		①									78.6	2.6×3.5 9.1	8.64	5.6	134
		②									63.3	7.3	8.67	5.7	137
		③									90.4	12.0	7.53	5.4	130

1 psi = 0.0069 MPa

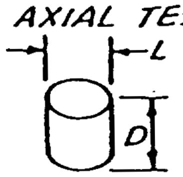
IRREGULAR LUMP TEST:



$D/L = 1.0 - 1.4$

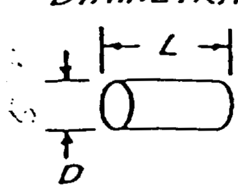
$D = 50\ mm$

AXIAL TEST:



$D/L = 1.1 \pm 0.05$

DIAMETRAL TEST:



$L/D > 1.4$

LABORATORY TEST RESULTS
SLAKE DURABILITY

PROJECT DSS PROJECT NUMBER 862 1806

BOREHOLE SAMPLE NUMBER X-1

TECHNICIAN M.O DATE NOV. 20/87

A S = SA dry = 579.8 D = DRUM(A) = 1719.5			SLAKE DURABILITY INDEX RETAINED (%) (A - D) / S x 100
AFTER CYCLES	A (S+D) (g)	A - D (g)	
1st	2297.0	577.5	99.6
2nd	2295.8	576.3	99.4
3rd	2294.4	574.9	99.2.
4th			
5th			

LABORATORY TEST RESULTS
SLAKE DURABILITY

PROJECT DSS PROJECT NUMBER 862 1806

BOREHOLE SAMPLE NUMBER X - 2

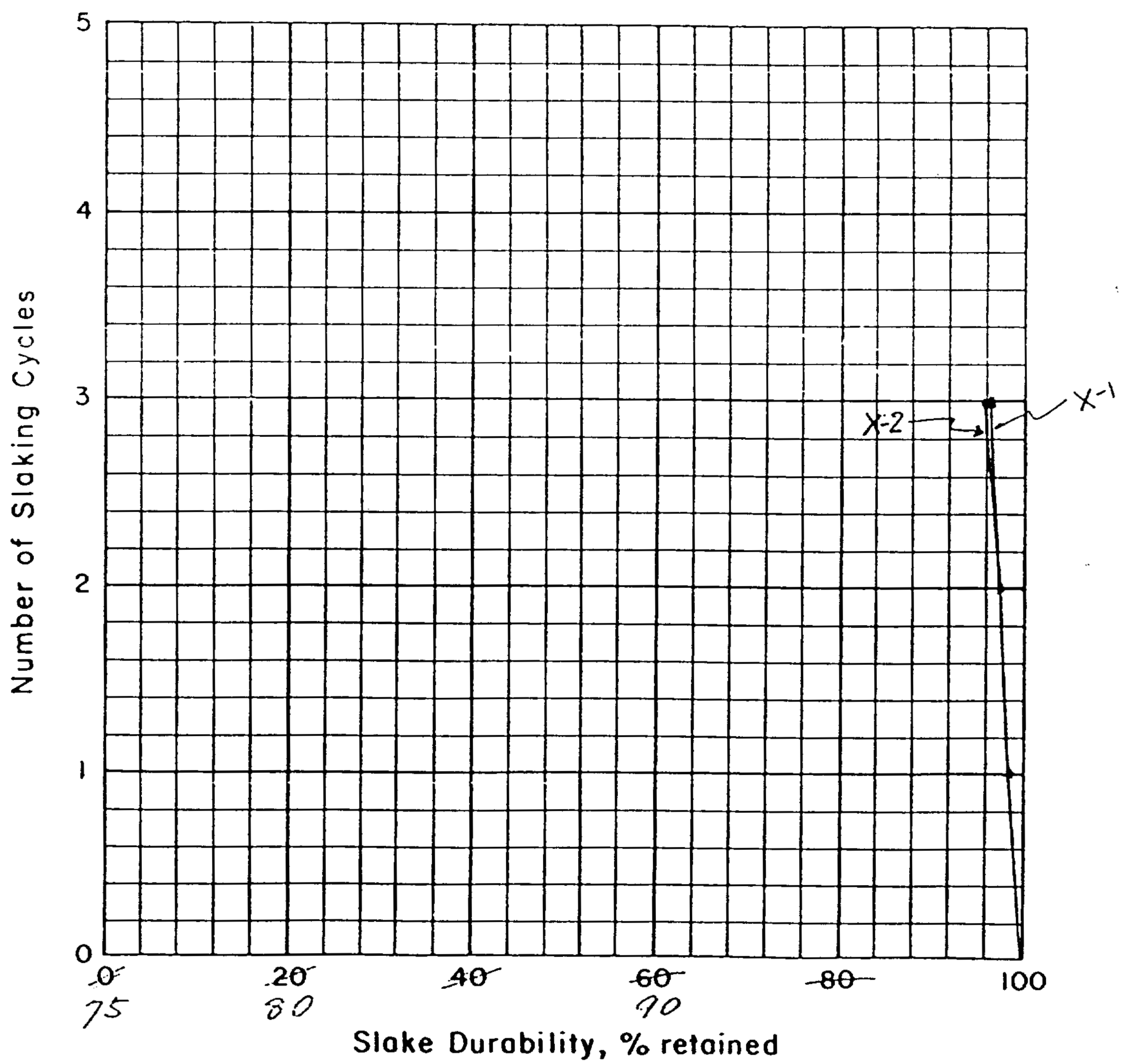
TECHNICIAN M.O DATE Nov. 20/87

B S = SA dry = 473.5 D = DRUM(A) = 1718.8			SLAKE DURABILITY INDEX RETAINED (%) $\frac{(A - D)}{S} \times 100$
AFTER CYCLES	A (S+D) (g)	A - D (g)	
1st	2190.3	471.5	99.6
2nd	2189.0	470.2	99.3
3rd	2187.7	468.9	99.0
4th			
5th			

SLAKE DURABILITY TEST	Figure

Project No.: 8621806
Client: DSS
Project: Quarries
Location: Beaufort

Date: Nov. 19/87
Drawn:



SOUNDNESS OF AGGREGATES
ASTM C88-76

☒ SODIUM SULPHATE
☐ MAGNESIUM SULPHATE

5 cycles

	PASS SIEVE	RETAINED SIEVE	WEIGHT (GMS)	PASS SIEVE	RETAINED SIEVE	ORIGINAL GRADING (%)	WEIGHT OF TEST FRACTION BEFORE TEST (GMS)	WEIGHT OF TEST FRACTION AFTER TEST (GMS)	AFTER TEST % PASSING	WEIGHTED % LOSS
COARSE AGGREGATE	2½	2	3025.7							
	2	1½	2016.1	2½	1½	68.3	5041.8	5038.0	0.08	0.05
	1½	1	1008.1							
	1	¾	505.2	1½	¾	17.0	1513.3	1506.0	0.48	0.08
	¾	½	667.0							
	½	⅜	334.0	¾	⅜	12.1	1001.0	993.5	0.66	0.08
	⅜	Nº4	304.6	⅜	Nº4	2.6	304.6	298.3	2.07	0.05
			7860.7			100%	7860.7			0.26
FINE AGGREGATE	⅜	Nº4								
	Nº4	Nº8								
	Nº8	Nº16								
	Nº16	Nº30								
	Nº30	Nº50								
	Nº50	Nº100								
	Minus Nº100									

COARSE AGGREGATE			QUALITATIVE EXAMINATION								
			SPLITTING		CRUMBLING		CRACKING		FLAKING		
	PASS SIEVE	RETAINED SIEVE	NO.	PERCENT	NO.	PERCENT	NO.	PERCENT	NO.	PERCENT	TOTAL Nº PARTICLE BEFORE TEST
	2½	1½									27
	1½	¾									56

REMARKS:

Golder Associates

SUBJECT
Job No. 862/806
Ref.
Made by M.O.
Checked
Reviewed
Date Nov. 27/87
Sheet of

SA : X 2

SOUNDNESS OF AGGREGATES
ASTM C88-76

☑ SODIUM SULPHATE
☐ MAGNESIUM SULPHATE

5 cycles

	PASS SIEVE	RETAINED SIEVE	WEIGHT (GMS)	PASS SIEVE	RETAINED SIEVE	ORIGINAL GRADING (%)	WEIGHT OF TEST FRACTION BEFORE TEST (GMS)	WEIGHT OF TEST FRACTION AFTER TEST (GMS)	AFTER TEST % PASSING	WEIGHTED % LOSS
COARSE AGGREGATE	2½	2	2313.7							
	2	1½	2183.4	2½	1½	53	4497.1	4492.6	0.10	0.05
	1½	1	1019.5							
	1	¾	506.9	1½	¾	31.8	1526.4	1522.9	0.23	0.07
	¾	½	673.5							
	½	⅜	330.1	¾	⅜	11.5	1003.6	999.8	0.38	0.04
	⅜	No 4	304.1	⅜	No 4	3.7	304.1	302.4	0.56	0.02
			3331.2			100%	7331.2			0.18
FINE AGGREGATE	⅜	No 4								
	No 4	No 8								
	No 8	No 16								
	No 16	No 30								
	No 30	No 50								
	No 50	No 100								
	Minus No 100									

	PASS SIEVE	RETAINED SIEVE	QUALITATIVE EXAMINATION: SPLITTING NO.	SPLITTING PERCENT	CRUMBLING NO.	CRUMBLING PERCENT	CRACKING NO.	CRACKING PERCENT	FLAKING NO.	FLAKING PERCENT	TOTAL No PARTICLES BEFORE TEST
COARSE AGGREGATE	2½	1½									31
	1½	¾									54

REMARKS:

Golder Associates

SUBJECT

Job No. 862/1806

Ref.

Made by M.O

Checked

Reviewed

Date Nov. 27/87

Sheet of

PROJECT 862-1806: PETROGRAPHY OF SAMPLES

REPORT #2

Peter B. Read

November 9, 1987

GEOTEX CONSULTANTS LIMITED consulting geologists

PROJECT 862-1806: PETROGRAPHY OF SAMPLES

REPORT #2

1. INTRODUCTION:

Golder Associates, 224 West Eighth Ave., Vancouver, B.C. supplied two hand specimens from sites X1 and X2. The rocks were examined as hand specimens under a binocular microscope and as thin sections under a petrographic microscope. Both rocks effervesce strongly under cold, dilute HCl.

2. PETROGRAPHY OF SAMPLE SUITE:

Folk's (1959) petrographic classification scheme for limestone was used. In this scheme, the constituents of limestone are subdivided into: (I) terrigenous constituents which include all material derived from erosion of source lands outside the basin of deposition; (II) allochemical constituents which cover all materials formed by chemical or biochemical precipitation within the basin of deposition; and (III) orthochemical constituents which consist of all essentially normal precipitates formed within the basin of deposition or within the rock itself and showing little or no evidence of significant transportation. This subdivision is then combined with the grain size of the rock and the composition of the carbonate to produce the terminology used in this report (Tables I and II and Fig. 1).

3. DESCRIPTIONS OF SAMPLES:

(a) Site 1:

Finely crystalline, medium grey biomicrite limestone containing fine bioclastic debris and sparry calcite cement.

Thin Section:

The following minerals are present in amounts given by a visually estimated mode:

1. Calcite (100%):

(a) Sparry calcite (35%): Shapeless, rhombohedrally twinned grains 0.5 to 0.8 mm in diameter which form irregularly shaped clots 5 to 20 mm long replacing biomicrite.

(b) Micrite (45%): Very fine, much, much less than 0.01 mm in diameter, shapeless grains.

(c) Bioclastic debris (20%): 0.5 to 1 mm long shell fragments of bivalves and crinoids.

(b) Sample X2:

Finely crystalline, medium grey crinoidal, biomicrite limestone.

Thin Section:

The following minerals are present in amounts given by a visually estimated mode:

1. Calcite (100%):

(a) Micrite (40%): Very fine, much, much less than 0.01 mm in diameter grains.

(b) Bioclastic debris (60%): 1 to 4 mm long fossil fragments which are mainly crinmoidal bdebris (pentacrinus? - if so, then the rocks would be of Triassic age) - bryozoan, and shell fragments of bivalves.

REFERENCES

Folk, R.L. (1959):
1959: Practical petrographic classification of limestones; Journal of Geology, v. 43, p. 1-38.

TABLE I. CLASSIFICATION OF CARBONATE ROCKS

Volumetric Allochem Composition	Limestones, Partly Dolomitized Limestones, and Primary Dolomites (see Notes 1 to 6): >10% Allochems, Allochemical Rocks (I and II): Sparry Calcite Cement > Microcrystalline Ooze Matrix — Sparry Allochemical Rocks (I)	Microcrystalline Ooze Matrix > Sparry Calcite Cement — Microcrystalline Allochemical Rocks (II)	<10% Allochems, Microcrystalline Rocks (III): 1-10% Allochems (Most Abundant Allochem)	<1% Allochems	Undisturbed Bioherm Rocks (IV)	Replacement Dolomites[7] (V): Allochem Ghosts (Evident Allochem)	No Allochem Ghosts
>25% Intraclasts (i)	Intrasparrudite (Ii:Lr) Intrasparite (Ii:La)	Intramicrudite* (IIi:Lr) Intramicrite* (IIi:La)	Intraclasts: Intraclast-bearing Micrite* (IIIi:Lr or La)	Micrite (IIIm:L); if disturbed, Dismicrite (IIImX:L); if primary dolomite, Dolomicrite (IIIm:D)	Biolithite (IV:L)	Finely Crystalline Intraclastic Dolomite (Vi:D3) etc.	Medium Crystalline Dolomite (V:D4)
<25% Intraclasts; >25% Oölites (o)	Oösparrudite (Io:Lr) Oösparite (Io:La)	Oömicrudite* (IIo:Lr) Oömicrite* (IIo:La)	Oölites: Oölite-bearing Micrite* (IIIo:Lr or La)			Coarsely Crystalline Oolitic Dolomite (Vo:D5) etc.	Finely Crystalline Dolomite (V:D3)
<25% Intraclasts; <25% Oölites; Volume Ratio of Fossils to Pellets >3:1 (b)	Biosparrudite (Ib:Lr) Biosparite (Ib:La)	Biomicrudite (IIb:Lr) Biomicrite (IIb:La)	Fossils: Fossiliferous Micrite (IIIb: Lr, La, or Ll)			Aphanocrystalline Biogenic Dolomite (Vb:D1) etc.	
<25% Intraclasts; <25% Oölites; Volume Ratio of Fossils to Pellets 3:1-1:3 (bp)	Biopelsparite (Ibp:La)	Biopelmicrite (IIbp:La)	Pellets: Pelletiferous Micrite (IIIp:La)			Very Finely Crystalline Pellet Dolomite (Vp:D2) etc.	etc.
<25% Intraclasts; <25% Oölites; Volume Ratio of Fossils to Pellets <1:3 (p)	Pelsparite (Ip:La)	Pelmicrite (IIp:La)					

NOTES TO TABLE I

* Designates rare rock types.

[1] Names and symbols in the body of the table refer to limestones. If the rock contains more than 10 per cent replacement dolomite, prefix the term "dolomitized" to the rock name, and use DLr or DLa for the symbol (e.g., dolomitized intrasparite, Li:DLa). If the rock contains more than 10 per cent dolomite of uncertain origin, prefix the term "dolomitic" to the rock name, and use dLr or dLa for the symbol (e.g., dolomitic pelsparite, Ip:dLa). If the rock consists of primary (directly deposited) dolomite, prefix the term "primary dolomite" to the rock name, and use Dr or Da for the symbol (e.g., primary dolomite intramicrite, IIi:Da). Instead of "primary dolomite micrite" (IIIm:D) the term "dolomicrite" may be used.

[2] Upper name in each box refers to calcirudites (median allochem size larger than 1.0 mm.); and lower name refers to all rocks with median allochem size smaller than 1.0 mm. Grain size and quantity of ooze matrix, cements or terrigenous grains are ignored.

[3] If the rock contains more than 10 per cent terrigenous material, prefix "sandy," "silty," or "clayey" to the rock name, and "Ts," "Tz," or "Tc" to the symbol depending on which is dominant (e.g., sandy biosparite, TsIb:La, or silty dolomitized pelmicrite, TzIIp:DLa). Glauconite, collophane, chert, pyrite, or other modifiers may also be prefixed.

[4] If the rock contains other allochems in [illegible] quantities that are not mentioned in the main rock name, these should be prefixed as qualifiers preceding the main rock name (e.g., fossiliferous intrasparite, oolitic pelmicrite, [illegible] oosparite, or intraclastic biomicrudite). This can be shown symbolically as Ii(b), Io(p), IIb(i), respectively.

[5] If the fossils are of rather uniform type or one type is dominant, this fact should be shown in the rock name (e.g., pelecypod biosparrudite, crinoid biomicrite).

[6] If the rock [illegible] can be shown to have recrystallized to microspar (5-15 micron, clear calcite) the terms "microsparite," "biomicrosparite," etc. can be used instead of "micrite" or "biomicrite".

[7] [illegible]

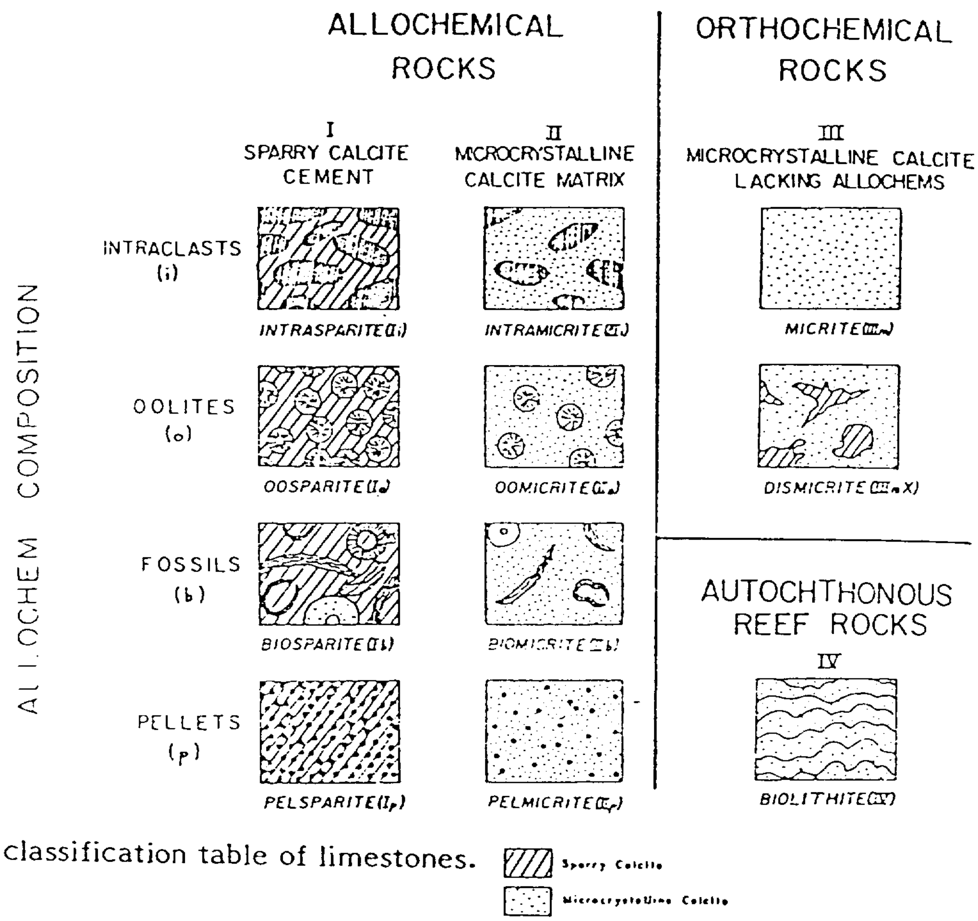


Figure 1: Graphic classification table of limestones.

Size	Transported Constituents	Authigenic Constituents	Size
	Very coarse calcirudite	Extremely coarsely crystalline	
64 mm			
	Coarse calcirudite		
16 mm			
	Medium calcirudite		
4 mm			4 mm
	Fine calcirudite	Very coarsely crystalline	
1 mm			1 mm
	Coarse calcarenite	Coarsely crystalline	
0.5 mm			
	Medium calcarenite		
0.25 mm			0.25 mm
	Fine calcarenite	Medium crystalline	
0.125 mm			
	Very fine calcarenite		
0.062 mm			0.062 mm
	Coarse calcilutite	Finely crystalline	
0.031 mm			
	Medium calcilutite		
0.016 mm			0.016 mm
	Fine calcilutite	Very finely crystalline	
0.008 mm			
0.004 mm	Very fine calcilutite		0.004 mm
		Aphanocrystalline	

TABLE II. GRAIN-SIZE SCALE FOR CARBONATE ROCKS

Carbonate rocks contain both physically transported particles (oolites, intraclasts, fossils, and pellets) and chemically precipitated minerals (either as pore-filling cement, primary ooze, or as products of recrystallization and replacement). Therefore, the size scale must be a double one, so that one can distinguish which constituent is being considered (e.g., coarse calcirudites may be cemented with very finely crystalline dolomite, and fine calcarenites may be cemented with coarsely crystalline calcite). The size scale for transported constituents uses the terms of Grabau but retains the finer divisions of Wentworth except in the calcirudite range; for dolomites of obviously allochemical origin, the terms "dolorudite," "dolarenite," and "dololutite" are substituted for those shown. The most common crystal size for dolomite appears to be between .062 and .25 mm, and for this reason that interval was chosen as the "medium crystalline" class.

Golder Associates
CONSULTING GEOTECHNICAL AND MINING ENGINEERS

E/88/0421

March 2, 1988

Natural Resources and Economic
Development Branch
Indian and Northern Affairs
Les Terrasses de la Chaudiere
6th Floor, 10 Wellington Street
Hull, P.Q.
K1A 0H4

ATTENTION: Mr. R.J. Gowan
Geotechnical Advisor

Re: Beaufort Region Quarry Rock Study
DSS File No. 38ST.A7134-6-0016
Revision Sheet to August, 1987 Report

Dear Mr. Gowan:

As requested, Golder Associates has carried out supplementary work on the existing quarries in the Inuvik area to complete the Beaufort Region quarry rock study. A number of comments made in our August, 1987 report require revising to reflect the results of this additional work. Readers of that report are advised that a supplementary report has been issued which contains revisions to Tables 6, 7, 8, 9, 10, 11 and 14, and Section 8 of the earlier report. This letter contains additional text revisions and should be appended to the original report.

Page 12, Paragraph 2: Delete last sentence.

Page 16, Delete first and second line.

Page 26, After first paragraph add a new paragraph.

"Los Angeles Abrasion tests were carried out by Public Works Canada in 1979 and 1980 on material taken from 'Campbell Lake Pit,' referred to in this report as Site XI, DPW Quarry. The results of this testing are shown on Table 8 and indicate conformance to the results of recent laboratory testing in that the limestone which outcrops east