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March 28, 1977

DEPUTY MINISTER OF MINES
& PETROLEUM RESOURCES

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ACTS			
A. D. M.	✓	1/4/	
A. D. P.			
M. R.			
E. & P.			
A. D.			

FILE

Consolidated Rexspar Minerals
& Chemicals Limited
20th Floor
4 King Street West
Toronto, Ontario
M5H 1C2

Attention: M. J. de Bastiani, P. Eng.
Vice-President, Technical
Operations, Denison Mines Ltd.

Dear Sir:

This will acknowledge and thank you for your letter of March 24, 1977 with which you enclosed three copies of the report of work carried out during 1976 by Consolidated Rexspar Minerals under Exploration Permit MX 51/69.

Yours sincerely,

N. S. Blackman

Mrs. N. S. Blackman

:sb
cc: Mrs. M. Kustka
Claims Supervisor, Exploration Division

Geological Survey of Canada

✓**Dept. Of Mines & Petroleum Resources**
Victoria, British Columbia

PROPERTY FILE

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Ottawa, Canada
K1P 5S9

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EXPLORATION PERMIT MX 51/69
82M|12W

CONSOLIDATED REXSPAR MINERALS AND CHEMICALS LIMITED

1976 SUMMARY REPORT

By

A. T. AVISON

To obtain material for metallurgical testing and better definition of the ore zones, 16 holes totalling 2,000 feet of core drilling was put down on the Rexspar property during 1976. The whole cores were shipped to Lakefield Research Limited where test work was carried out under the direction of A. H. Ross & Associates. Site investigation of the proposed mine site and mill site and environmental studies were carried out by Kilborn Engineering (B.C.) Limited.

CORE DRILLING

The detailed geology logs and sample analyses are attached. The drill hole locations are shown on the accompanying plan. The drill program summary follows:

Hole No.	Size	Lat.	Depth	Bearing	Dip	Length Feet
76-A-1	HQ	24628	24970	-	90°	70
76-A-2	HQ	24880	24970	-	90°	165
76-A-3	HQ	25000	25115	270°	89°	73
76-A-4	HQ	25050	25000	-	90°	118
76-A-5	HQ	25110	25110	270°	89°	73
76-B-1	HQ	25400	23850	0°	89°	133
76-B-2	HQ	25360	23930	-	90°	93
76-BD-1	HQ	24350	23355	-	90°	97
76-BD-2	HQ	24400	23480	-	90°	145
76-BD-3	HQ	24488	23500	0°	89°	168
76-BD-4	HQ	25525	23370	-	90°	107
76-BD-5	BQ	24700	23275	090°	60°	203
76-BD-6	BQ	24650	23290	-	90°	153
76-BD-7	BQ	24550	23325	270°	60°	150
76-BD-8	BQ	24250	23315	-	90°	126
76-BD-9	BQ	24250	23440	-	90°	126

METALLURGICAL TESTS

The test results are presented in the attached report by A. H. Ross & Associates. The recommended process consists of crushing and grinding at the mine site, pipeline slurry movement to the mill on the North Thompson River and uranium recovery using the atmospheric leach system, solvent extraction and precipitation. The presence of fluorite in the ore will require some modifications to the flow sheet.

Additional test work to refine the flow sheet design and cost estimates is planned.

A. T. Avison

A. T. Avison

22 March 1977
Toronto, Ontario.

CONSOLIDATED REXSPAR MINERALS & CHEMICALS LIMITED

Evaluations Pertaining To General Flowsheet Selection For Uranium Ore Processing

R.C. Swider, P. Eng.

W.V. Barker, P. Eng.

K.R. Coyne, P. Eng.

Toronto, Ontario, Canada

February, 1977

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Attachments

1. Ontario Research Foundation Letter Report
2. Colorado School of Mines Research Institute Letter Report

1. INTRODUCTION

1.1 Preface

The A.H. Ross & Associates report of June 13, 1975, "A Preliminary Economic Study of Uranium Recovery from Rexspar Ore", recommended that a metallurgical test program be undertaken if further consideration were to be given to this project. Consolidated Rexspar Minerals & Chemicals Limited subsequently requested A.H. Ross & Associates to proceed with laboratory test work to develop the preferred flowsheet.

Investigations on samples from the Rexspar property had been carried out from 1951 to 1958. All prior metallurgical reports were reviewed in detail in preparation for undertaking the laboratory studies. Authors of the early reports had concluded that the Rexspar ore is not amenable to conventional uranium processing techniques.

The 1952-1955 laboratory work demonstrated extractions exceeding 90% of the U_3O_8 present by leaching in an autoclave at 140°C using water and oxygen as the only reagents. Based on that work, the 1956-1958 investigations developed a flowsheet for pressure acid leaching in towers. The studies were not sufficiently complete to permit design of a commercial plant with confidence. Knowledge of suitable materials of construction and of ability to meet fluoride specifications in yellow cake was lacking.

The metallurgical testwork performed in 1976 by Lakefield Research of Canada and by Colorado School of Mines Research Institute under the direction of A.H. Ross & Associates had the objective of establishing the preferred flowsheet based on uranium and other hydrometallurgical plant experience in the intervening years. Sample material was drill core from three holes drilled in 1975 and nine holes drilled in 1976. Results of the testwork to date allow approximate evaluation of the economics of a recommended flowsheet. Additional work will be required to develop design criteria and to define suitable materials of construction.

1.2 Premises

The capital and operating costs are based upon recovery from an average ore assay of 0.075% U_3O_8, 20% pyrite and 3% fluoride. The flowsheet has been premised on the production of a low sodium yellow cake which would be acceptable feed material at all North American uranium refineries.

The costs have been developed on the basis of processing 365,000 tons per year of ore (1,000 TPD). The capital cost estimate does not include any facilities associated with ore mining activities, haulage, tailings disposal area, access roads, electrical power supply, warehouse, maintenance shops, change house, administration office, townsite or employee housing. The operating costs do not include chemicals for treatment of tailings to forestall future acid drainage. All costs are premised on present monetary values without any allowance for inflation.

1.3 Reports of Metallurgical Test Work

A formal report on laboratory results has not yet been prepared by Lakefield Research of Canada Limited. Laboratory test data sheets which report details of grinding and leaching have been used for this preliminary evaluation. Results of work by two other laboratories are presented in the following letter reports:

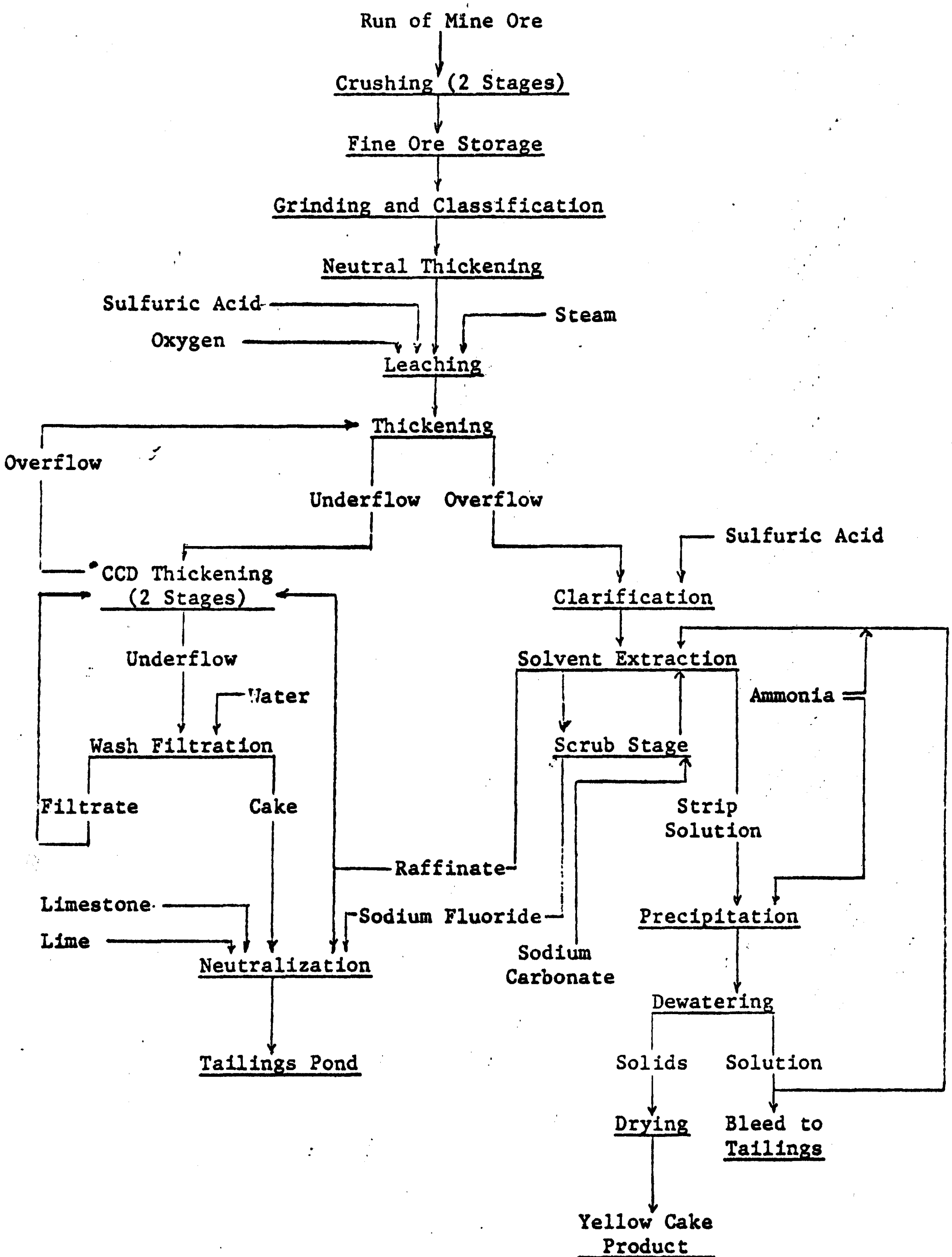
October 19, 1976 Ontario Research Foundation Re: Bond Grindability Test on Consolidated Rexspar Ore.

January 14, 1977 Colorado School of Mines Research Institute Re: Preliminary Studies on Solvent Extraction of Fluoride Bearing Uranium Leach Solution.

1.4 Flowsheet

The generalized schematic flowsheet is shown on the following page.

Schematic Flowsheet



2.2 Metallurgy

2.2.1 Autoclave Leaching with Oxygen

The Rexspar uranium ore samples used for the laboratory testwork reported in Section 3 of this report had high sulfide, fluoride and acid neutralizing components, similar to those reported from earlier work by others. These ore characteristics make the use of any of the conventional uranium extraction processes uneconomic. However, it had been found that high uranium recovery could be achieved at temperatures of 130 - 140^{o}C without any reagents other than 10 psia of oxygen which provides the oxidant and which also reacts with the sulfides to produce the acid needed for leaching.

The testwork at Lakefield Research of Canada Limited in 1976 confirmed effective extraction of 93 to 95% of the uranium in an autoclave under those conditions. However, some of the ore samples responded less readily than others, and required the presence of some acid to initiate the reaction.

The autoclave process, while chemically feasible, presents great difficulty in equipment design to meet the severe conditions of erosion and corrosion in the presence of sulfuric and hydrofluoric acid at 140^{o}C. An extensive pilot scale development would be needed before the autoclave leach process could be recommended for use in the commercial plant.

2.2.2 Atmospheric Leaching with Oxygen

A range of temperature below 100^{o}C for leaching was explored. It was found that extractions of 90 to 92% of the uranium could be achieved at atmospheric pressure, if about 100 pounds of sulfuric acid per ton of ore and some ferric sulfate were present.

These conditions, while more severe than customarily used in the uranium industry, are potentially within the range of some elastomer linings now available for steel vessels.

The atmospheric leach system is recommended for the extraction of uranium from Rexspar ore. A program of testwork based on this preferred leach system is required to develop the information for the detailed design of the commercial plant.

2.2.3 The Fluoride Problem

Fluoride dissolved from the ore results in about 1 to 4 gpl in the pregnant solutions from the batch leach tests, and thus there is more fluoride than uranium present. The early testwork had indicated that high fluoride content in yellowcake resulted when precipitation from ion exchange eluate was practiced. The alternative of solvent extraction with a tertiary amine was explored in the current test program. It is indicated that the fluoride specification can be met when yellowcake is produced by precipitation from strip solution from an amine solvent extraction process. The fluoride, however, must be scrubbed from the organic phase with an alkaline solution, which increases the reagent consumption in the process.

2.4 Comments

2.4.1 While the testwork reported herein has confirmed the superior economics predicted for high temperature pressure leaching of Rexspar uranium ore by previous investigators, adoption of that process route entails a pioneering effort, with considerable risk of equipment failure. The long term pilot plant testing for development of suitable construction materials, which would be required, is probably not warranted for an ore deposit of the size of Rexspar.

Approximately four months more laboratory work will be required to develop the design data required for the 90°C atmospheric leach system. Cost estimates in the subsequent sections of this report are based on a selected set of leach conditions which should be confirmed or altered somewhat for optimization. Thickening and filtration testwork remain to be done. Design criteria for solvent extraction and precipitation must be developed.

2.4.2 The leach temperature of 90°C is higher than that considered acceptable by the industry for an economic life of the rubber linings currently used in steel pachuca tanks. The successful operation of the leach described herein will depend on finding a lining material and method of application to steel which will serve well enough to permit uninterrupted operation of the leach with reasonable maintenance. There is reason to think that chlorobutyl rubber would provide such service. Major elastomer manufacturers may have other potential materials. A test program under commercial conditions is planned on this important aspect of the project.

2.4.3 The costs of chemicals for leaching are relatively high because of the presence of pyrite and of acid consuming minerals including carbonates. Commercially pure oxygen has been found to be effective as the oxidant and by reacting with the pyrite, generates some of the acid required for the leach. Examination of the economics of oxygen supply shows it is advantageous to purchase an oxygen plant, to be installed at the millsite, rather than to purchase liquid oxygen, to be trucked 600 or 700 miles from the nearest commercial sources. However, the sulfuric acid is available by tank car from several suppliers and is assumed to be purchased.

2.4.4 In the proposed solvent extraction circuit, it is expected that most of the fluoride will transfer from the pregnant solution to the solvent, and that it will not be stripped from the solvent with the uranium. An alkaline scrub of the solvent to remove the fluoride will probably be required. It is assumed that soda ash will be used, and the sodium fluoride solution obtained will be directed to the tailings neutralization system, where the fluoride will be precipitated as calcium fluoride.

2.4.5 Tailings neutralization as practiced at the Elliot Lake uranium mills is included in the flowsheet. However, the unusually large amount of pyrite remaining in the tailings has environmental implications which involve considerations of ultimate rehabilitation of the tailings area. There has been no provision for these costs in this report.

3. METALLURGICAL TEST DATA

3.1 Ore Sample

The sample material consisted of diamond drill core obtained during 1975 and 1976 from the Rexspar property near Birch Island, British Columbia. In February 1976 work was begun at Lakefield Research of Canada Limited on 1975 drill core, which was identified as one hole in each of ore zones A, B and BD. The core sent to Lakefield Research of Canada Limited in July and August 1976 was identified as originating in four holes in zone A, two holes in zone B and four holes in zone BD. A composite sample of each hole was prepared taking half of each section in the ore zone. After analysis of the hole composites, approximately 200 kg of a master composite sample was prepared for the leach test program. The master composite consisted of 47% zone A ore, 14% zone B ore and 39% zone BD ore, in accordance with the 1975 ore estimates by Kilborn Engineering Limited. All holes were represented, but slightly less sample taken from the higher grade holes in order to hold the average calculated U_3O_8 content down to 1.5 lb. per ton. Analyses of drill core are given in Table I.

3.2 Grinding

Leach test work was carried out at grinds ranging from 40% to 95% minus 200 mesh. Variations in grind within that range does not appear to have a significant effect on rate of autoclave leaching. Effect of grind on atmospheric leach with oxygen requires further study, as there are indications of improved extraction rates with finer grinds. However, several successful atmospheric leaches were done on ore ground to the following screen analyses.

Screen Size, Tyler Mesh	65	100	150	200	270	400
Cumulative % by Wt. Passing	96	87	76	61	53	41

TABLE I ANALYSES OF 1975 AND 1976 DIAMOND DRILL CORE

Sample	U_3O_8	Fe	S	F	CO_2	SiO_2	Al_2O_3	CaO	Mg O	Cu
	Percent									
Zone B 75-1	0.065	16.5	15.0	4.6	0.66	22.0	7.2	8.6	7.2	0.059
Zone A 75-2	0.071	11.9	10.6	4.0	3.52	27.4	9.5	9.6	8.1	0.058
Zone BD 75-4	0.040	5.1	4.4	1.3	3.23	49.3	14.6	5.7	2.3	0.020
Comp. 75-124	0.062	11.4	10.3	3.4	3.20					
76-A-1	0.181	14.2	14.4	3.9	0.07					
76-A-2	0.072	9.7	9.9	3.6	2.14					
76-A-3	0.100	11.8	10.8	3.2	0.15					
76-A-5	0.092	11.8	12.3	2.0	0.05					
76-B-1	0.052	13.6	11.5	3.8	1.89					
76-B-2	0.063	12.5	7.7	3.1	0.60					
76-BD-2	0.068	10.2	8.3	2.4	0.85					
76-BD-3	0.094	15.6	13.1	4.0	3.10					
76-BD-4	0.065	14.4	13.2	4.1	2.67					
Composite 1	0.074		10.5		1.20					
Composite 2	0.081		11.3		1.40					
Master Composite	0.078	12.1	10.3	2.9	0.70					

Data on the ore Work Index was gathered in a number of ways. These were:

A standard Bond Work Index determination was made by the Ontario Research Foundation. The results were reported in their letter of October 19, 1976, Attachment I. The test was by dry ball milling to pass 100 mesh with 250% circulating load. The presence of micaceous material in the oversize meant that an excessive number of cycles was required to reach equilibrium, resulting in an unusually high work index of 18.7.

By comparative open circuit wet grinding in a batch laboratory ball mill against a reference ore of known work index at Lakefield Research of Canada Limited.

By use of the Mergan mill manufactured by Outokumpu OY. This unit measures the net energy consumption, during grinding at constant mill speed, by a pendulum type torque meter with recording of DC current.

The various results obtained by these methods are tabulated below for a grinding circuit product size of 60% passing 200 mesh:

Method	Sample	Grindability Work Index
1. Standard Bond Work Index (ORF)	76-B-1	18.7
2. Laboratory Comparative Grinding	76-A-1	8.2
	76-A-2	9.1
	76-A-3	8.7
	76-A-5	9.2
	76-B-1	9.7
	76-B-2	8.4
	76-BD-2	8.8
	76-BD-3	8.3
	76-BD-4	8.3
	Master Composite	9.9
3. Mergan Mill	Hole 76-B-1	8.3
	Master Composite	7.5

The standard Bond Work Index (ORF) is most commonly accepted for design purposes but its use in this case would undoubtedly result in oversizing the mill. A more reasonable choice would be a grindability index of 10.

3.3 Leaching

3.3.1 General

The leaching test work involved two separate programs. The first was to verify that good extraction of uranium could be achieved reliably by continuous leaching in autoclaves. The second program sought conditions for a successful leach at lower temperature, which would allow the use of proven materials of construction and conventional equipment.

The test work has demonstrated two effective leaching alternatives:

Autoclave leaching with oxygen and little or no external source of acid, at 140° C for 4 to 6 hours.

Atmospheric leaching with oxygen and 50 to 100 pounds of sulfuric acid per ton of ore, at 90° C for 24 to 48 hours.

On the assumption that equipment for both leach systems can be designed at a practical cost, an approximate preliminary evaluation of economics favours autoclave leaching, principally because of better extraction. The comparison is shown in Table XVII. However extensive inquiry to suppliers has so far not revealed any materials which will withstand the severe erosive and corrosive conditions of the autoclave leach. The atmospheric leach at 90° C is still a difficult application as the temperature is 10 to 15 degrees higher than the usual limit for rubber lined steel. However, some recent experience in other industries with chlorobutyl rubber lined steel at 90 to 100° C indicates that it may be suitable for this application.

The consumption of acid by Rexspar ore is quite high. It was measured by agitating samples in dilute sulfuric acid at 400 lb acid per ton of ore for 4 hours at ambient temperature. The filtrate from the slurry was then back titrated with sodium hydroxide to pH 2.5, to permit calculation of net acid consumption. The figures, given in Table II do not indicate any direct relationship between acid consumption and carbonate content.

TABLE II ACID CONSUMPTION

Sample	CO_2 %	Acid Consumption lb/ton
76-A-1	0.07	268
76-A-2	2.14	308
76-A-3	0.15	260
76-A-5	0.05	256
76-B-1	1.89	274
76-B-2	0.60	276
76-BD-4	2.67	266

3.3.2 Autoclave Leach With Oxygen

Composite samples, representing all the 1976 drill holes combined, responded well to autogenous autoclave leaching. The method has been described in numerous reports of previous metallurgical test work on samples from the Rexspar property at Birch Island. Reference is made particularly to "Laboratory Investigation on Treatment of Rexspar Uranium Ore", Final Report by J. Halpern Department of Mining and Metallurgy, University of British Columbia, August 15, 1955. The results of all five tests done on 1976 composite samples at Lakefield Research were in the range of 93 - 95% extraction in 6 hours at 140°C, with 10 psi oxygen overpressure and no addition of acid, as shown in Table III. It can be seen that grind had little influence in the range 41 to 67% minus 200 mesh.

TABLE III AUTOCLAVE LEACH TESTS ON COMPOSITE SAMPLES 1976 DRILLING

Test Conditions:

50% solids in water, no acid addition
Temperature 140°C
Oxygen overpressure 10 psi

Test No.	Sample	Grind % - 200 mesh	Leach Time in hr.	% U_3O_8 Head	% U_3O_8 Residue	% Extraction
A33	Composite 1	67	6	0.074	0.005	93
A34	Composite 2	65	6	0.081	0.005	94
A36	Master Comp.	61	2	0.078	0.024	69
			4		0.007	91
			6		0.004	95
A38	Master Comp.	54	2	0.078	0.021	73
			4		0.008	90
			6		0.004	95
A37	Master Comp.	41	2	0.078	0.032	59
			4		0.008	90
			6		0.005	94

Because some samples from the 1975 drilling program had failed to respond to autogenous autoclave leaching under the same conditions, it was decided to check the behaviour of ore samples from each of the 1976 drill holes for individual differences. There appeared to be some correlation to carbonate content in 1975 drill core samples, but work with 1976 drill core has not confirmed this. The results are given in Table IV.

The autoclave leach, with autogenous generation of the sulfuric acid leachant by reaction of pyrite with oxygen and water, was effective in all but test A24 on hole 76-A-2. However, as shown in Table V, excellent uranium extraction was obtained from the same sample in test A25 by initiating the reaction with an addition of 50 pounds of sulfuric acid per ton of ore. Extending the leach time to 12 hours in test A30 was also effective indicating the problem is simply a delay in the development of free acid in the solution, which may be related to unusually high reactivity of oxides or carbonates in the sample.

Table VI shows the poor extraction of U_3O_8 from some high CO_2 samples without the use of acid. The samples are from 1975 drill core, except sample 4452 from hole 76-BD-4. Table VIII shows conditions for good extractions by use of acid in the autoclave even if the CO_2 content is high. High CO_2 sample 4444 in this table is from hole 76-BD-3; in this case good extraction was achieved without acid.

There does not seem to be any necessity for selective mining to avoid the problem, as it may only be necessary to provide for occasional use of acid in the pressure leach if autoclave leaching is adopted.

TABLE IV AUTOCLAVE LEACH TESTS, INDIVIDUAL DRILL HOLES 1976

Test Conditions:

50% solids in water, no acid addition
Temperature 140°C
Oxygen overpressure 10 psi

Test No.	Hole No.	% U_3O_8 Head	% U_3O_8 Residue	% Extraction
A20	76-A-1	0.181	0.005	97
A21	76-A-3	0.100	0.006	94
A22	76-A-5	0.092	0.003	97
A23	76-B-2	0.063	0.007	89
A24	76-A-2	0.072	0.064	11
A26	76-B-1	0.052	0.004	92
A27	76-BD-4	0.065	0.004	94
A28	76-BD-3	0.094	0.003	97
A29	76-BD-2	0.068	0.003	96

TABLE V AUTOCLAVE LEACH TESTS, SAMPLE FROM HOLE NO. 76-A-2

Test Conditions:

50% solids in water
Temperature 140°C
Oxygen overpressure 10 psi

Test No.	Hole No.	Time hr	Acid Added lb/ton	% U_3O_8 Head	% U_3O_8 Residue	% Extraction
A24	76-A-2	6	0	0.072	0.064	11
A25	76-A-2	6	50	0.072	0.002	97
A30	76-A-2	12	0	0.072	0.011	85

TABLE VI AUTOCLAVE LEACH TESTS - LOW U_3O_8 EXTRACTIONS IN 6 HOURS

Test No.	Sample	% CO_2	% Solids	Acid lb/ton	Temp. °C	Oxygen psi	Final pH	% Extraction
A1	75-124	3.2	50	0	150	10	5.9	17
A7	75-124	3.2	50	Note	150	30	3.0	21
A11a	75-124	3.2	50	0	140	10	7.0	0
A11b	75-124	3.2	30	0	150	30	7.0	0
A13a	75-2	3.5	50	0	140	10	7.0	0
A14a	75-4	3.2	50	0	140	10	7.0	0
A14b	75-4	3.2	50	50	140	10	7.0	0
A16	75-124	3.2	50	0	150	10	6.3	0
A32	4452	2.8	50	0	140	10	5.8	10

Note: 5 gpl Fe^{+++} as sulfate, acidified to prevent hydrolysis

TABLE VII AUTOCLAVE LEACH TESTS - HIGH U_3O_8 EXTRACTIONS IN 6 HOURS

Test No.	Sample	% CO_2	% Solids	Acid lb/ton	Temp. °C	Oxygen psi	Final pH	% Extraction
A4	75-124	3.2	10	Note	150	30	1.2	97
A11c	75-124	3.2	30	25	150	30	1.7	84
A12	75-1	0.7	50	0	140	10	1.1	94
A13b	75-2	3.5	50	100	140	10	1.3	88
A18	75-4	3.2	50	150	140	10	1.3	95
A31	4444	3.9	50	0	140	10	1.1	96

Note: 5 gpl Fe^{+++} as sulfate, acidified to prevent hydrolysis

3.3.3 Atmospheric Leach With Oxygen

Although excellent extraction of uranium is readily achieved by autoclave leaching with oxygen, no successful plant of this kind is known. Hence a lower temperature alternative to autoclave autogenous leaching was sought. The metallurgical studies on Rexspar ore in 1951 to 1958 had not used the temperature range of 75^{o} to 100^{o}C for leaching, and it was decided to explore the possibilities in this range.

Preliminary tests on 1975 drill core reported in Table VIII showed that an initial addition of sulfuric acid and ferric sulfate would start the reaction between oxygen and pyrite at 90^{o}C. Sufficient acid was then generated autogenously to leach U_3O_8 at a reasonable rate. In these early tests the slurry density was difficult to control because of high temperature, long leach time and excessive evaporation from the stirred flask.

To simulate oxygen introduction at depth in pachucas under atmospheric pressure, apparatus was constructed to carry out leach tests by diffusing commercial oxygen into the bottom of two inch diameter by 20 foot high pyrex glass columns. Slurry density and temperature control were good, the columns being electrically heated by current through resistance wire wound around the glass.

TABLE VIII PRELIMINARY LEACH TESTS WITH OXYGEN AT ATMOSPHERIC PRESSURE

Conditions:

Mechanical agitation in three-neck flask, oxygen bubbling into the pulp at 90°C. Poor control of slurry density.

Test No.	Sample	% Solids	Acid lb/ton	Fe^{+++} gpl	Time hr	% U_3O_8 Head	% U_3O_8 Residue
A2	75-124	50	0	0	96	0.062	0.056
A5	75-124	10	115	5	96	0.062	0.008
A9	75-124	25	135	5	48	0.062	0.011
A15	75-1	40	60	2	24	0.065	0.021
					48		0.010

Results of the preliminary atmospheric leach tests in the glass column given in Table IX indicated autogenous leaching was possible at 90°C on some samples at least, and that excellent extraction could be obtained in 48 hours, using 100 lb acid per ton of ore.

Exploration of the effect of increasing acid additions is detailed in Table X. Failure to achieve a satisfactory leach at 80°C is shown by data in Table XI. Tests reported in Table XII indicated there was no particular advantage in raising the leach temperature a few degrees, approaching 95°C. Agitation with air, rather than pure oxygen was found to be less effective, as reported in Table XIII.

The series of tests reported in Table XIV was based on the information developed from all the other series. These tests confirmed that high extractions can be achieved consistently at 90°C under a variety of conditions of pulp density and fineness of grind with retention times of 48 hours or less. The conditions for Test C27, 90°C, 30% solids and a grind of 61% minus 200 mesh were chosen for the capital and operating cost estimates for this report.

TABLE IX PRELIMINARY ATMOSPHERIC LEACH TESTS WITH OXYGEN IN THE GLASS COLUMN

Conditions:

Slurry at 50% solids agitated by oxygen introduced at a depth of 12 feet, temperature held at 90°C

Test No.	Sample	Grind %-200m	Acid lb/ton	Fe^{+++} gpl	Time hr	Final pH	% U_3O_8 Head	% U_3O_8 Residue
A17a	75-2	(-35m)	0	0	7	6.7	0.071	0.071
A17b	75-2	(-65m)	40	2	7	6.0	0.071	0.067
A19	75-1	(-65m)	40	0	6	2.5	0.065	0.042
C1	76-A-1	74	50	0	48	1.4	0.181	0.011
C2	76-A-5	64	50	0	24	1.7	0.092	0.024
C3	76-A-5	64	0	0	24	1.9	0.092	0.020
C4	76-A-5	64	0	0	54	1.3	0.092	0.016
C5	76-A-2	68	0	0	96	7.1	0.072	0.072
C6	Comp 1	67	100	0	48	1.3	0.074	0.005

TABLE X COLUMN LEACH TESTS WITH INCREASING ADDITIONS OF ACID

Conditions:

Master composite sample at 50% solids, agitated with oxygen, temperature held at 90° C.

Test No	Grind %-200m	Acid lb/ton	Fe^{+++} gpl	Time hr	Final pH	Residue % U_3O_8	% Extraction
C8	61	50	0	88	1.8	0.035	55
C7	61	100	0	48	1.5	0.037	53
				72	1.6	0.019	76
				88	1.4	0.008	90
C12	61	100	Note 1	48	1.8	0.018	77
				72	1.5	0.017	78
				90	1.5	0.007	91
C20	61	100	Note 2	48	2.1	0.025	68
				74	1.6	0.016	79
				90	1.3	0.007	91
C11	61	150	0	90	1.5	0.018	77
C21	83	150	0	48	2.1	0.024	69
				74	1.4	0.010	87
				90	1.3	0.005	94
C17	61	200	0	90	2.0	0.027	65
C18	61	300	0	44	1.7	0.025	68
				70	1.5	0.007	91
				90	1.4	0.006	92
C22	83	300	0	48	1.6	0.006	92
				74	1.4	0.005	94
				90	1.3	0.005	94
C19	61	300	5	25	1.3	0.007	91
				48	1.6	0.005	94
				74	1.4	0.004	95
				90	1.4	0.004	95

Notes

(1) Leachant included 50% of recycled C7 pregnant solution

(2) Leachant included 50% of recycled C12 pregnant solution

TABLE XI ATMOSPHERIC LEACHING WITH OXYGEN AT 80°C

Conditions:

Slurry of master composite sample at 50% solids, agitated by oxygen, temperature held at 80°C

Test No	Grind %-200m	Acid lb/ton	Fe^{+++} gpl	Time hr	Final pH	Residue % U_3O_8	% Extraction
C9	61	50	0	88	1.7	0.063	19
C10	61	100	0	88	2.0	0.037	53
C14	61	100	Note	90	1.7	0.047	40
C31	61	100	10	47	1.8	0.049	37
C32	83	100	10	47	1.7	0.052	33

Note: Leachant included 50% of recycled C10 pregnant solution.

TABLE XII COLUMN LEACHING AT TEMPERATURES HIGHER THAN 90°C

Conditions:

Master composite sample at 50% solids, agitated by oxygen

Test No	Grind %-200m	Acid lb/ton	Fe^{+++} gpl	Temp. °C	Time hr	Final pH	Residue % U_3O_8	% Extraction
C24	83	100	5	91-93	12	1.6	0.032	59
					24	1.8	0.019	76
					36	1.4	0.010	87
					48	1.6	0.007	91
C23	61	100	5	93-94	12	1.9	0.039	50
					24	1.9	0.030	62
					36	1.6	0.023	71
					48	1.8	0.016	79
C16	61	250	0	93-94	44	1.9	0.035	55
					70	1.8	0.015	81
					90	1.5	0.006	92
C15	61	150	0	94-95	44	2.1	0.032	59
					70	1.7	0.021	73
					90	1.4	0.005	94

TABLE XIII OXIDATION WITH AIR COMPARED WITH OXYGEN AT ATMOSPHERIC PRESSURE

Conditions:

Master composite sample
100 lb/ton acid and 5 gpl Fe^{+++} initially
Temperature 90°C

Test Numbers	Grind % -200 mesh	% Solids	Time hr	Residue % U_3O_8 Oxygen	Residue % U_3O_8 Air
C26,C29	61	40	12	0.013	0.033
			24	0.009	0.026
			36	0.008	0.033
			48	0.008	0.032
C25,C30	83	50	12	0.033	0.037
			24	0.015	0.035
			36	0.008	0.032
			48	0.007	0.030

TABLE XIV ATMOSPHERIC LEACH WITH OXYGEN - DEFINITIVE TESTS

Conditions:

Master composite sample at 50% solids, agitated by oxygen, temperature held at 90°C

Test No	Grind % -200m	% Solids	Acid lb/ton	Fe^{+++} gpl	Time hr	Residue % U_3O_8	% Extraction
C25	83	50	100	5	12	0.033	58
					24	0.015	81
					36	0.008	90
					48	0.007	91
C26	61	40	100	5	12	0.013	83
					24	0.009	88
					36	0.008	90
					48	0.008	90
C27	61	30	100	5	12	0.010	87
					24	0.008	90
					36	0.007	91
					48	0.006	92
C28	61	40	50	5	12	0.042	46
					24	0.038	51
					36	0.027	65
					48	0.011	86
C33	61	50	100	10	12	0.011	86
					24	0.008	90
					36	0.007	91
					48	0.007	91
C34	95	50	100	5	12	0.022	72
					24	0.008	90
					36	0.006	92
					48	0.007	91

3.3.4 Chemicals Consumed in Leaching

3.3.4.1 Sulfuric Acid

Results of tests on composite samples show that all the acid required for leaching can be autogenously generated at 140° C by reaction of oxygen and pyrite. Hence in cost comparisons of operating conditions presented in Section 4, no cost is charged for purchased sulfuric acid for autoclave leaching with oxygen.

In the atmospheric leach with oxygen at 90° C, the test results indicate that an initial addition of sulfuric acid is required. The optimum amount of acid has not been clearly established; good extractions are obtained with an initial addition of 100 lb acid per ton of ore, but 50 lb per ton is not enough. In the proposed flowsheet, recycle of pregnant solution provides 20 lb acid per ton of ore, and the required ferric sulfate. Hence an addition of 80 lb acid per ton is the amount used in the operating cost estimates in Section 6.

3.3.4.2 Oxygen

Oxygen consumption during leaching has not yet been measured directly. However, oxygen consumption has been estimated on the basis of a calculation of the amount required to oxidize the pyrite to yield ferric iron, elemental sulfur and sulfate. From several tests which gave high extractions, leach residues were analyzed for residual sulfide and for elemental sulfur. The amount of sulfate formed was obtained from the relationship to the original total sulfur in the head sample. Using this data, the amount of reacted oxygen was calculated.

The results for autoclave leaching at 140°C are given in Table XV and for atmospheric leaching in Table XVI. The average for the five autoclave tests is 100 lb oxygen per ton of ore. For the purpose of this report the oxygen requirement is estimated to be 110 lb per ton at 140°C. For comparison, J. Halpern's final report on Rexspar tests from University of British Columbia, August 15, 1955, and Mines Branch report SR-475/57 state that 60 lb of sulfur per ton of ore needs to go to sulfate, which would require about 120 lb oxygen per ton.

The average for the six atmospheric leaching tests is 44 lb oxygen per ton of ore. For the purpose of this report, the oxygen requirement is estimated to be 50 lb per ton at 90°C.

TABLE XV CALCULATED OXYGEN CONSUMPTION IN AUTOCLAVE LEACHING AT 140°C

Test No.	U_3O_8 Extraction %	Sulfide Sulfur: Ore lb/ton	Sulfide Sulfur: Residue lb/ton	Oxidized S in Residue: Elemental S lb/ton	Oxidized S in Residue: Sulfate S lb/ton	Calculated Oxygen Used lb/ton
A33	93	210	128	12	70	136
A34	94	226	163	14	49	97
A36	95	206	151	26	29	64
A37	94	206	143	23	40	84
A38	95	206	139	4	63	119
					Average	100

TABLE XVI CALCULATED OXYGEN CONSUMPTION IN ATMOSPHERIC LEACHING AT 90°C

Test No.	U_3O_8 Extraction %	Sulfide Sulfur: Ore lb/ton	Sulfide Sulfur: Residue lb/ton	Oxidized S in Residue: Elemental S lb/ton	Oxidized S in Residue: Sulfate S lb/ton	Calculated Oxygen Used lb/ton
C18	92	206	175	13	18	38
C19	95	206	178	4	24	46
C22	94	206	175	10	21	43
C24	91	206	173	12	21	44
C27	92	206	169	12	25	51
C33	91	206	180	6	20	40
					Average	44

3.4 Behaviour of Fluoride

3.4.1 Mines Branch Reports on Rexspar, 1957 and 1958

The following comments are quoted:
"Precipitates made so far from Rexspar ion exchange eluate have shown high fluoride content, well above specifications". Report IR-236/57, page 2.

"Final product of 80% U_3O_8 - the fluoride content was well over specification. Alternative precipitation methods did not reduce fluoride to an acceptable level." "Four yellow cakes at 1.5, 1.09, 0.94 and 0.5% fluoride". Report SR-476/57 page 4 and page 36.

"SX triisooctylamine; precipitates 0.15, 0.16, 0.11 and 0.14% F." Report IR 58-86, page 16.

"SX by alamine - only the fluorine assay is somewhat higher than the specification limit of 0.10 part F per 100 parts U_3O_8. The assay indicates 0.104". Report IR-58-178, page 5.

3.4.2 Lakefield Research Shake-out Test

Autoclave leach test A22 on hole composite 76-A-5 resulted in 97% U_3O_8 extraction and 3.23 gpl F in the pregnant solution. Heads had 0.092% U_3O_8 and 2.04% F.

Column leach test C1 on hole composite 76-A-1 resulted in 94% U_3O_8 extraction and 2.40 gpl F in the pregnant solution. Heads had 0.181% U_3O_8 and 3.87% F.

Pregnant solution samples from these two leach tests were used for shake-out solvent extraction tests, in which the fluoride behaviour was followed.

Organic extraction solution (2½% Alamine 336, 2½% isodecanol in Shell 140 kerosene) was sulfated with dilute sulfuric acid at pH 1.5. The organic was then neutralized with 130 gpl solution of ammonium sulfate at pH 4.

The solvent was contacted several times with fresh portions of a pregnant solution to saturate the solvent with U_3O_8. The solvent was then stripped with the ammonium sulfate solution. Yellow cake was precipitated from the strip solution by addition of ammonium hydroxide to pH 7. Strip solution and filtrate from yellow cake were analyzed for fluoride. Each was found to contain less than 0.03 gpl fluoride, the limit of detection by the method used.

3.4.3 Comments from General Mills Chemicals, Inc.

The use of General Mills' tertiary amine in a solvent extraction process to recover uranium from leach solutions containing approximately 0.5 gpl U_3O_8 and up to 4 gpl fluoride was discussed with Mr. Wayne Jensen. He stated that as fluoride is an anion which attaches very strongly to the tertiary amine, it will almost all go into the organic. With a strip solution on the acid side, fluoride will not strip with uranium; only a few parts per million fluoride would be expected in the strip solution. To keep the fluoride from building up in the organic, there should be a scrub stage, using ammonium hydroxide or sodium carbonate which will strip the fluoride from the solvent.

Mr. Jensen knew of no experience in the uranium industry with as much fluoride in leach solution.

3.4.4 Colorado School of Mines Research Institute Studies

Five gallons of undiluted pregnant solution from leach tests at Lakefield Research of Canada Limited was sent to CSMRI for scoping tests on the extent of fluoride transfer to a yellow cake product produced by the amine solvent extraction process. The CSMRI letter on this study is Attachment 2 to this report. It concludes that "yellow cake product prepared by conventional amine extraction (Alamine 336) and $(NH_4)_2\ SO_4 + NH_3$ stripping indicated no serious contamination problems due to fluoride".

The leach solution analysis is given as 0.46 gpl U_3O_8 and 1.26 gpl F. The yellow cake product was found to contain only 0.006 % F.

It should be noted that solution scrubbing applied in the CSMRI work was with neutral $(NH_4)_2SO_4$ solution, whereas a basic solution should be used to remove fluoride from the solvent.

In the course of the CSMRI testwork, it was noted that certain difficulties with extraction emulsions and yellow cake product slurry filtration were found to occur.

No design data was expected or obtained from the preliminary SX testwork.

ATTACHMENT 1

ONTARIO RESEARCH FOUNDATION

..IERIDAN PARK, MISSISSAUGA, ONTARIO, CANADA L5K 1B3 PHONE (416) 822-4111 OR 279-9771 * TWX 610-492-2524

October 19, 1976

A.H. Ross & Associates
1706-80 Richmond Street West
Toronto, Ontario
M5H 2A4

Attention: Mr. W.V. Barker

Dear Sir:

Re: Bond Grindability Test on
Consolidated Rexspar Ore
Our Investigation No. MP-76363

We have completed the Bond dry grindability test on the sample of Consolidated Rexspar ore received from Lakefield Research and found the work index to be 18.71. Initial tests were done at 200 mesh but there was a build-up of micaceous material in the oversize which meant that equilibrium was not reached after 12 cycles. After a conversation with Mr. Bergman at Allis Chalmers Research Centre, Milwaukee, further tests were done at 100 mesh which resulted in near equilibrium conditions being reached.

The work index was calculated according to the Bond formula:

$$Wi = \frac{44.5}{P_1^{0.23} \times G_pR^{0.82}\left(\frac{10}{\sqrt{P}} - \frac{10}{\sqrt{F}}\right)}$$

where:

Wi	=	Work index	= 18.71
P_1	=	Screen size tested in microns	= 147
G_pR	=	Net grams of undersize produced per revolution of test mill	= 1.033
P	=	Screen size in microns which 80% of test product passes	= 102
F	=	Screen size in microns which 80% of test feed passes	= 1540

The power consumption was calculated according to the Bond formula:

$$W = \frac{10\ Wi}{\sqrt{P}} - \frac{10\ Wi}{\sqrt{F}}$$

where: W = kilowatt hours to grind one short ton of material to pass test screen size with 250% circulating load = 13.76

The structures of the test feed and test product are listed on the attached table.

If you have any questions regarding this or any other matter please do not hesitate to contact us.

Yours very truly,

P.D.R. Maltby

P.D.R. Maltby, P.Eng.
Assistant Director
Department of Metallurgy

PDRM:jc

STRUCTURE OF -6 MESH BOND MILL FEED

Mesh Size	Wt. %	% Passing
8	8.1	91.9
10	10.4	81.5
14	10.4	71.1
20	12.2	58.9
28	10.9	48.0
35	8.8	39.2
48	6.8	32.4
65	5.7	26.7
100	5.5	21.2
150	2.8	18.4
200	3.6	14.8
270	2.8	12.0
-270	12.0	-
Head	100.0	

STRUCTURE OF BOND MILL PRODUCT (-100 MESH)

Mesh Size	Wt. %	% Passing
150	19.5	80.5
200	18.3	62.2
270	12.7	49.5
400	22.3	27.2
-400	27.2	-
Head	100.0	

ATTACHMENT 2

Colorado School of Mines Research Institute

P.O. BOX 112 • GOLDEN, COLORADO 80401
PHONE (303) 279-2581 CSMRI

January 14, 1977

CSMRI Project A61146

Mr. W. V. Barker
Project Engineer
A. H. Ross & Associates
1706-80 Richmond Street West
Toronto, Ontario M5H 2T4
Canada

Dear Mr. Barker:

The purpose of this letter is to report the results of our preliminary work on a fluoride bearing uranium leach solution. The objectives of this study have been to evaluate the extent of fluoride transfer to a yellow cake product produced by the amine SX process, and to determine if solvent poisoning problems exist.

The sample received for this study consisted of 18 l of solution (in polyethylene), received on November 24, 1976. The scope of the work was limited to bench scale tests designed to evaluate and correct a suspected fluoride transfer and product contamination problem.

The results of this work indicate that fluoride contamination of the product was not a problem. However, certain difficulties with extraction emulsions and difficulties in obtaining efficient uranium stripping, were found to occur.

SUMMARY AND CONCLUSIONS

The following statements are based on the results of preliminary studies with a fluoride bearing uranium leach solution.

1. Yellow cake product prepared by conventional amine extraction (Alamine 336) and $(NH_4)_2SO_4 + NH_3$ stripping indicated no serious contamination problems due to fluoride. Fluoride contamination which occurred in a product prepared from unscrubbed organic was 0.006%F.

2. The effect of scrubbing loaded organic prior to stripping and product recovery was marginal and apparently unnecessary. The best yellow cake product obtained via this route (5g/l $(NH_4)_2SO_4$ solution scrubbing) contained 0.003% F.

3. Extraction contacts with the sponsor's feed solution resulted in nearly stable emulsions on the 3rd contact, under contact conditions of A/O=2. An emission spectrographic scan of organic free emulsion solids showed Mg to be major, with strong traces of Al, Ca, Si, Cu, Fe and Mn. Anionic components could not be analyzed due to limited material.

4. The results from cyclic loading and stripping contacts indicated that there were no definite interferences preventing uranium extraction.

5. Extracted uranium appeared to strip from the organic with more difficulty than has been experienced in other work. Causitive factors in this have not been determined.

6. The yellow cake product slurry was dispersed at pH 7.5-8.0, and was relatively difficult to recover by direct filtration.

RECOMMENDATIONS

Although efficient U_3O_8 stripping has been shown to be somewhat of a problem, a much greater problem is expected from emulsion formation during extraction.

It is recommended that work be done in the area of pretreatment of the solution, as a possible means of reducing this emulsion tendency. This type of study might be approached by the trial use of fluoride precipitating agents (CaO or RE_2O_3) or metals such as silica or titanium which might form more stable fluorides in solution.

RESULTS AND DISCUSSION

Solution Sample Description and Analysis

The solution used for this study was supplied by Lakefield Research of Canada Limited. Five gals. of solution was received November 24, 1976. The "as received" solution was very clear, with a light yellowish green color. The pH of the solution was 1.9 and had the following composition.

Solution Analysis

Elements	g/l
F	1.26
Al	1.6
Fe	1.4
Mg	5.6
Mo	<0.002
V	0.015
SiO_2	0.5
U_3O_8	0.46

A small amount of precipitate had settled to the bottom of the 5 gal. container due to standing.

Behavior of Uranium and Fluoride During Process Steps

The objective of this portion of the study was to determine the extent of an assumed F transfer to yellow cake products, and to simultaneously scope variable scrubbing solutions to alleviate this potential condition.

The test sequence was designed to apply multiple contact loading of a single volume of organic (using the solution sample submitted), and to divide the loaded organic into 3 equal parts. The organic volume fractions were then treated separately with a control sample, to study the effects of 2 separate scrubbing solutions. Following the scrubbing contacts each organic volume was stripped using $(NH_4)_2$ SO_4+NH_3 (pH 4.2-4.4) and yellow cake precipitated with NH_4OH at pH 7.5-8.0, filtered, dried and analyzed for F. Raffinates, scrub solutions and filtrates were also analyzed for F in order to obtain a balance.

Test Conditions and Procedure

The test conditions used in each of these steps are listed as follows.

Organic Composition

Alamine 336	2.5 V/V%
Isodecanol	2.5 V/V%
Kerosine (SacoSol 175)	95.0 V/V%

Extraction Conditions

A/O Ratio	2
Contact time	2 min.
Temperature	ambient
No. of contacts	3
Loaded organic	2.452 g/l U_3O_8

Scrubbing Conditions

O/A ratio	1
Contact time	2 min.
Temperature	ambient
No. of contacts	2
Scrub solutions	(a) 5 g/l $(NH_4)_2SO_4$ (pH 5.5) (b) 50 g/l Na_2SO_4 (pH set to 1.5 with H_2SO_4)

U_3O_8 Stripping Conditions

Scrubbed organic	2.4 g/l U_3O_8
O/A ratio	3.5
Contact time	10 min.
Temperature	ambient
No. of contacts	1
Strip solution	130 g/l $(NH_4)_2SO_4$ plus NH_4OH to pH 4.2-4.4

The organic was preconditioned by sulfating prior to extraction contacts. Following each step in the process the organic phases were clarified by filtration, prior to further treatment.

Behavior of Uranium During Process Steps

The results of this work, as concerned with U_3O_8 transfer during the process steps, is listed as follows.

Solution	Analysis, g/l U_3O_8
Aqueous feed	0.46
Loaded organic	2.448
Combined extraction raff	0.025

Solution	Analysis, g/l U_3O_8
Scrubbed organics;	
non-scrubbed	---
$(NH_4)_2\ SO_4$ scrubbed	possible trace (NA)
Na_2SO_4 scrubbed	possible trace (NA)
Stripped organics;	
non-scrubbed	0.17
$(NH_4)_2SO_4$ scrubbed	0.10
Na_2SO_4 scrubbed	0.095

From this, it can be seen that U_3O_8 stripping was unusually difficult. Under the test conditions used we would normally expect to obtain 0.005 to 0.030 g/l U_3O_8 in the stripped organic, with a very high percentage of U_3O_8 stripped. Compared to this, our testwork has shown U_3O_8 stripping in the order of 93%.

Another problem noted in this work was the behavior of yellow cake during filtration. All of the individual strip concentrate solutions produced a dispersed or colloidal type precipitate when raised to pH 7.5-8.0 with NH_4OH. Filtration of these solids required several passes through a No. 42 Whatman paper, and even then left a slightly cloudy filtrate. On standing between filtrations the solids did settle reasonably well, but never became flocculated well enough for efficient filtration. No flocculants were used in this step because normal yellow cake solids behave well on a buchner filter and this particular problem was unexpected.

Emulsion Problems During Extraction

Of additional concern in the extraction step was the pronounced tendency toward emulsion formation. It is recognized that an extraction contact at an A/O of 2 enhances emulsion tendencies. However, in this work, the repeated extraction contacts (3) led to more severe emulsion problems with each subsequent contact. Emulsion in the first two contacts were broken almost completely by heating in a water bath. The third contact resulted in such a stable emulsion that centrifuging was required, yielding approximately 90% of the components as clear liquid. The paste-like fraction recovered was further treated to remove aqueous soluble components as well as organic, and the residue analyzed by semi-quantitative emission spectrograph.

Elements found to be present in this analysis were as follows:

Element	% By Range (1) T	TX	TXX	m	M
Al			x		
Cu			x		
Fe			x		
Pb		x			
Mn			x		
Ni	x				
Si			x		
Ti	x				
U		x			
V	x				
Zn		x			
Ca			x		
Mg				x	

1/ M = +10%
m = 1-10%
TXX = 0.1-1%
TX = 0.01-0.1%
T = 0.001-0.01%

The small quantity of solids recovered made it impossible to analyze for elements such as P, F and SO_4.

Behavior of Fluoride During Process Steps

The behavior of fluoride during the process steps is shown by the following balance data.

Fluoride Balance

Fluoride Input;
Aqueous feed; 6.2 l aq. feed x 1.26 g/l = 7.812 g

Calculated Fluoride Loading;
Total Raffinate 6.2 l x 1.24 g/l = 7.689 g
Calc. L.O. 1.1 l x 0.112 g/l = 0.123 g

Fluoride Out;

Scrub aqueous;		
Total $(NH_4)_2SO_4$ scrub	0.73 l x 3.9 ppm = 0.0028 g	
Total Na_2SO_4 scrub	0.73 l x 3.0 ppm = 0.0022 g	
Yellow cake filtrate plus wash;		
Non-scrubbed org.	0.115 l x 87.0 ppm = 0.0100 g	
$(NH_4)_2SO_4$ scrubbed org.	0.129 l x 29.0 ppm = 0.0037 g	
Na_2SO_4 scrubbed org.	0.153 l x 26.0 ppm = 0.0040 g	
Yellow cake product;		
Non-scrubbed org.	≈ 1.2 g x 0.006%	0.00007 g
$(NH_4)_2SO_4$ scrubbed org.	≈ 1.2 g x 0.004%	0.00005 g
Na_2SO_4 scrubbed org.	≈ 1.2 g x 0.003%	0.00004 g
	Total F out	0.02286 g

The preceding fluoride balance is based on the assumption of full recovery of components through the process steps. From this data it can be seen that a balance cannot be obtained between the calculated loaded organic and the sum of fluoride found in various solutions and solids. This indicates that the difference in fluoride was a part of the insoluble solids occurring in extraction emulsion solids.

The preceding data also shows that fluoride contamination did not transfer through extraction and into the final yellow cake product.

Cyclic U_3O_8 Loading-Stripping Tests

As a part of this work program it was of importance to determine if soluble components in the feed might tend to irreverably load, and eventually poison the organic.

For this study a series of extraction contacts (by shakeout) and stripping contacts (by agitated beaker contacts) were conducted in a sequential manner. The organic was loaded in the first 5 tests by 5 contacts at an O/A of 1.3. In a final test the organic was loaded by 8 contacts at an O/A of 1.3. All stripping contacts were conducted at an O/A of 3.0, with the addition of NH_4OH to a pH of 4.2-4.4 in a 10-minute contact period. The initial U_3O_8 barren strip solution (containing 130 g/l $(NH_4)_2SO_4$) was re-used for each of 6 cycles.

Following loading and stripping contacts the clarified organic was analyzed for U_3O_8.

The results of these tests are listed as follows:

Cycle No.	Loaded Organic g/l U_3O_8	Stripped Organic g/l U_3O_8	Calc. Cumulative Strip Concentrate g/l U_3O_8
1	1.48	0.03	4.35
2	1.48	0.018	10.20
3	1.48	0.016	16.05
4	1.48	0.016	21.90
5	1.48	0.06	27.58
6	2.30	0.32	35.50
		0.09 (1)	

1/ double stripped using fresh U_3O_8 barren solution for second contact

Based on this data, there appears to be no serious difficulty in recycling the organic and obtaining reasonable strip efficiency, up to a U_3O_8 concentration of ≈30 g/l in the strip concentrate. A double strip of cycle 6 organic returned the barren organic to 0.09 g/l, which was the approximate average for earlier stripping tests. The 0.09 g/l U_3O_8 value in the barren organic is only slightly higher than normal, and cannot be predicted as a definite poisoning problem.

We have stopped work on this project with 5 l of the original feed solution on hand. This quantity was held against possible future work.

Please let me know if you have any questions concerning this report.

Very truly yours,

H D Peterson

H. D. Peterson
Project Manager
Chemical Division

/vsc

DRILL HOLE LOG

PROPERTY Cons. Rexspar HOLE NO. 76-A-1

LA- 24, 628 N. DIP -90° HOLE STARTED July 14/76

DEP. 24, 970 E. AZIMUTH HOLE FINISHED July 15/76

ELEV. 4000' LOGGED BY Dr. E, L. Evans LENGTH 70' SIZE HQ

FOOTAGE	DESCRIPTION	SAMPLE NO.	LENGTH	FROM	TO	U_3O_8
	XXXX XXX					
0 - 4.0	Overburden	068	5'	33	38	0.320
4.0-18.0	Trachyte-Weathered Moderate radioactivity core recovery < 50%	069	5'	38	43	0.085
18.0-41.5	Trachyte-dark, schistose with occasional fragment of lighter coloned material. 20% pyrite moderately high radioactivity 23.4-26.0 Coarse fragmental light blue in color. Highly radioactive	070 071 072 073	5' 5' 5' 10'	43 48 53 58	48 53 58 68	0.071 0.016 0.023 0.011
41.5-70.0	Trachyte-Coarse fragmental with light colored fragments 10% pyrite. One inch veinlet of chalcopyrite at 59.2'	064 065 066 067		0 18 23 28	18 23 28 33	0.008 0.178 0.200 0.239
	End of Hole					

DRILL HOLE LOG

PROPERTY Cons. Rexspar

HOLE NO. 76-A-2

LAT 24,880 N.

DIP 90°

HOLE STARTED July 15/76

DEP. 24,970 E

AZIMUTH

HOLE FINISHED July 17/76

ELEV. 4000'

LOGGED BY Dr. E. L. Evans

LENGTH 165'

SIZE HQ

FOOTAGE	DESCRIPTION
0 - 1	Overburden
6 - 8	Trachyte-rust stained and broken
8 - 31.7	Trachyte-grey, schistose-schecticity at 10° to core 5% pyrite
31.7-48.8	Trachyte-altered schistose, dark grey 30% pyrite much rust in spots
48.8-57.5	Trachyte-less altered, less schistose some large, light coloured feldspar fragments, Fluorite seam 3/4" at 49.1
	fluorite
57.5-73.0	Trachyte-dark to medium grey fresh with patches of/ Bedding about 10% to core 5-10% pyrite but with patches up to 30%. Rock has a bluish cart which may be due to fine fluorite
73-78	Trachyte-dark grey to black with roughly 35% pyrite and high radioactivity 76.8-78 high fluorite content
78-88	Trachyte-massive with moderate pyrite and fluorite
88-92.5	Trachyte-grey, massive with white feldspar crystals 90-92.5 high fluorite content
92.5-103	Trachyte-grey and highly fractured moderate pyrite
103-118	Trachyte-dark schistose-some large light coloured fragments in chlorite matrix. Highly radioactive 25% pyrite 117.9-118.5 abundant fluorite
118-152.5	Trachyte-coarser fragmental, somewhat schictose 15% pyrite
152.5-157.3	Trachyte-finer texture and darker in color from 155 moderate pyrite
157.3-165	Trachyte-light grey with large fragments. Pyrite in patches and streaks.
	End of Hole

SAMPLE NO.	LENGTH	FROM	TO	U_3O_8
021	5'	30	35	0.005
022	5'	35	40	0.001
023	5'	40	45	0.003
024	3.8'	45	48.8	0.005
025	4.9'	48.8	53.7	0.074
026	4.3'	53.7	58	0.064
027	5'	58	63	0.025
028	5'	63	68	0.015
029	5'	68	73	0.037
030	5'	73	78	0.113
031	5'	78	83	0.026
032	5'	83	88	0.023
033	4'	88	92	0.015
034	6'	92	98	0.020
035	5'	98	103	0.032
036	5'	103	108	0.143
037	5'	108	113	0.100
038	5'	113	118	0.103
039	5'	118	123	0.083
040	5'	123	128	0.056
041	5'	128	133	0.084
042	5'	133	138	0.023
043	5'	138	143	0.007
044	5'	143	148	0.015
045	5'	148	153	0.024
046	5'	153	158	0.034

DRILL HOLE LOG

PROPERTY Cons. Rexspar

HOLE NO. 76-A-3

L[illegible] 25,000 N.

DIP -89^0

HOLE STARTED July 10/76

DEP. 25,115 E.

AZIMUTH 270^0

HOLE FINISHED July 11/76

ELEV. 3,930

LOGGED BY Dr. E. L. Evans

LENGTH 73' SIZE HQ

FOOTAGE	DESCRIPTION	SAMPLE NO.	LENGTH	FROM	TO	U_3O_8
	XXXX XXX					
0 - 8	Overburden	095	5'	8	13	0.130
8 - 9.5	Trachyte - weathered	096	5'	13	18	0.180
9.5- 2.3	Trachyte 1/2" X 1 1/2" fragments	097	5'	18	23	0.082
	schictose with very heavy	098	5'	23	28	0.102
	pyrite - grey	099	5'	28	33	0.083
23 -33.4	Trachyte - highly altered - bleached and	100	5'	33	38	0.011
	schictose in spots, micaceous with moderately heavy	101	5'	38	43	0.023
	pyrite	102	5'	43	48	0.023
33.4-50	Trachyte - coarse fragmental with abundant pyrite	103	5'	48	53	0.061
	in interstices	104	5'	53	58	0.094
50 -73	Trachyte-dark with coarse fragments, abundant pyrite	105	5'	58	63	0.074
	and patches of fluorite. Highly radioactive	106	5'	63	68	0.100
	56-58 possible fault	107	5'	68	73	0.020
	72-73 fault zone					
	End of Hole					

DRILL HOLE LOG

PROPERTY Cons. Rexspar

HOLE NO. 76-A-4

LAT 25,050 N.

DIP -90°

HOLE STARTED July 12/76

DEP. 25,000 E.

AZIMUTH

HOLE FINISHED July 13/76

ELEV. 3950'

LOGGED BY Dr. E. L. Evans

LENGTH 118' SIZE HQ

FOOTAGE	DESCRIPTION	SAMPLE NO.	LENGTH	FROM	TO	U_3O_8
0 - 8	Overburden	074	3'	18	21	0.028
8 - 21	Trachyte-massive light blue with fragments up to 1/2"	075	3'	21	24	0.005
	Core fractured - 1% pyrite	076	4'	24	28	0.013
		077	5'	28	33	0.015
21- 24	Trachyte-dark colored tuff with low radioactivity	078	5'	33	38	0.012
		079	5'	38	43	0.009
		080	5'	43	48	0.013
24- 60	Trachyte-grey,even grained with pea sized fragments	081	5'	48	53	0.008
	Moderate pyrite some fluorite in spots, moderate	082	5'	53	58	0.010
	radioactivity	083	5'	58	63	0.014
		084	5'	63	68	0.014
		085	5'	68	73	0.021
		086	5'	73	78	0.016
60- 92	Trachyte-similar to above except for coarse fractur-	087	5'	78	83	0.014
	ing at 45° to core axis and much rust stainery 70-	088	5'	83	88	0.023
	71.5 altered and rust stained - possible fault	089	5'	88	93	0.052
		090	5'	93	98	0.039
		091	5'	98	103	0.019
		092	5'	103	108	0.008
92-118	Trachyte-light grey, highly fractured - 5% pyrite	093	5'	108	113	0.007
	92-93 possible fault	094	5'	113	118	0.007
	99-101 malachite stain on fractures					
	End of Hole					

DRILL HOLE LOG

PROPERTY Cons. Rexspar

HOLE NO. 76-A-5

LAT. 25,110 N.

DIP -98^{0}

HOLE STARTED July 9/76

DEP. 25,110 E.

AZIMUTH 270^{0}

HOLE FINISHED July 10/76

ELEV. 3,900'

LOGGED BY Dr. E. L. Evans

LENGTH 73' SIZE HQ

FOOTAGE	DESCRIPTION	SAMPLE NO.	LENGTH	FROM	TO	U_3O_8
0 - 10	Overburden	108	3'	10	13	0.052
10 - 13	Trachyte-weathered	109	5'	13	18	0.091
13 - 23	Trachyte - heavy pyrite mineralization slightly	110	5'	18	23	0.196
	schictose and highly radioactive	111	5'	23	28	0.023
		112	5'	28	33	0.018
		113	5'	33	38	0.058
23 - 36.6	Trachyte - fine grained, grey cut by quartz	114	5'	38	43	0.067
	veinlets moderate pyrite	115	5'	43	48	0.080
		116	5'	48	53	0.097
36.6-48	Trachyte-coarse agglomerate with abundant	117	5'	53	58	0.135
	pyrite	118	5'	58	63	0.090
		119	5'	63	68	0.045
48 - 73	Trachyte-medium agglomerate abundant pyrite,	120	5'	68	73	0.010
	some fluorite					
	63-73' less pyrite					
	End of Hole					

DRILL HOLE LOG

PROPERTY Cons. Rexspar

HOLE NO. 76-B-1

LAT 25,400 N

DIP -89°

HOLE STARTED July 19/76

DEP. 23,850 E

AZIMUTH 0°

HOLE FINISHED July 20/76

ELEV. 3,825

LOGGED BY E. L. Evans

LENGTH 133' SIZE HQ

FOOTAGE	DESCRIPTION (From / To)
0-8'	Casing
8'-16'	Trachite: grey fractured and weathered. Shows spotted alteration.
16'-37'5"	Trachite: grey, spotted with about 3% pyrite.
37'5"-46'5"	Trachite: dark grey fragmental with about 5% pyrite.
46'5"-58'3"	Trachite: very dark, tuffacious with up to 25% pyrite.
58'3"-64'	Trachite: Massive grey fragmental, 60'-62' schisted and altered with schistosity at 50° to core.
64'-93'	Trachite: dark grey, altered and schistose. About 15% pyrite, schistosity 50% to core at 68' - 30% pyrite.
93'-103'	Trachite: light grey core badly broken.
103'-113'	Trachite: light grey with dark sections to chlorite in breccia matrix.
113'-126'	Trachite: dark grey fragmental, slightly schistose - 10% pyrite.
126'-133'	Trachite: light grey with dark fractured sections.
133'	End of Hold

SAMPLE NO.	LENGTH	From	To		
4401	5'	38'	43'		
4402	5'	43'	48'		
4403	5'	48'	53'		
4404	5'	53'	58'		
4405	5'	58'	63'		
4406	5'	63'	68'		
4407	5'	68'	73'		
4408	5'	73'	78'		
4409	5'	78'	83'		
4410	5'	83'	88'		
4411	5'	88'	93'		
4412	5'	93'	98'		
4413	5'	98'	103'		

DRILL HOLE LOG

PROPERTY Cons. Rexspar

HOLE NO. 76-B-2

LAT. 25,360 N.

DIP 90°

HOLE STARTED July 18/76

DEP. 23,930 E.,

AZIMUTH

HOLE FINISHED July 19/76

ELEV. 3,850

LOGGED BY Dr. E. L. Evans

LENGTH 93' SIZE HQ

FOOTAGE	DESCRIPTION	SAMPLE NO.	LENGTH	FROM	TO	U_3O_8
0 - 8	Overburden ~~XXXX~~ ~~XXX~~	047	5'	13	18	0.004
8 - 40	Trachyte-light grey, fairly massive but	048	5'	18	23	0.012
	cut by fractures 5% pyrite, sparce fluorite	049	5'	23	28	0.005
		050	5'	28	33	0.009
40-46	Trachyte-coarse fragmental dark grey chloritic	051	5'	33	38	0.005
	10% pyrite	052	5'	38	43	0.008
	46-46.8 fault	053	5'	43	48	0.071
46-61.4	Trachyte-dark, coarse grained with abundant	054	5'	48	53	0.059
	muscovite and fairly heavy pyrite	055	5'	53	58	0.071
	very strong radioactivity	056	5'	58	63	0.050
		058	5'	63	68	0.052
61.4-70.1	Trachyte-dark, schictose-15% pyrite	059	5'	68	73	0.026
	strong radioactivity	060	5'	73	78	0.006
		061	5'	78	83	0.005
70.1-93	Trachyte-coarse agglomerate 15% pyrite, some	062	5'	83	88	0.006
	muscovite moderate radioactivity	063	5'	88	93	0.011
	sparce fluorite					
	End of Hole.					

DRILL HOLE LOG

PROPERTY Cons Rexspar | HOLE NO. 76-BD-1

LAT 24,350 N 7' W of map | DIP -90° | HOLE STARTED August 5/76

DEP. 23,355 E location | AZIMUTH | HOLE FINISHED August 8/76

ELEV. 3450 | LOGGED BY E. L. Evans | LENGTH 97' SIZE HQ

FOOTAGE	DESCRIPTION (From / To)	SAMPLE NO.	LENGTH	From	To		
0-14'	Casing						
14'-49'	Trachite: Rusted and altered with limonite streaking. Some short sections of grey fragmental.	4414	5'	23	28		
49'-66'	Trachite: grey fragmental with fragments oriented at 80° to core.						
66'-78'	Trachite: greenish-grey agglomerate with elongated fragments at 60° to core.						
78'-84'	Trachite: green, fine grained. Patch of flourite at 80°.						
84'-97'	Trachite: blue and green fragmental, moderate pyrite to 89', thereafter heavy pyrite.						
97'	End of Hole						

DRILL HOLE LOG

PROPERTY Cons Rexspar — HOLE NO. 76-BD-2

LAT. 24,400 N — DIP -90° — HOLE STARTED July 28/76

DEP. 23,480 E — AZIMUTH — HOLE FINISHED July 30/76

ELEV. 3430 — LOGGED BY E. L. Evans — LENGTH 145' — SIZE HQ

FOOTAGE	DESCRIPTION	SAMPLE NO.	LENGTH	From	To
	From To				
0-27	Casing				
27-29	Trachite: badly broken and weathered	4415	3'	30	33
		4416	5'	33	38
29-50	Trachite: grey green with abundant fractures, weak pyrite.	4417	5'	38	43
		4418	5'	43	48
		4419	5'	48	53
50-77	Trachite: Dark grey fragmented with 25% pyrite. Fluorite patch at 63'. Schistosity at 60° to core.	4420	5'	53	58
		4421	5'	58	63
		4422	5'	63	68
		4423	5'	68	73
77-107	Trachite: Mixed dark grey and light grey fragmental. Schistose. 25% pyrite.	4424	5'	73	78
		4425	5'	78	83
		4426	5'	83	88
107-127	Trachite: grey, fine grained with occassional seam of massive pyrite. 120-124 contains patches of quartz. Fluorite at 119'8".	4427	5'	88	93
		4428	5'	93	98
		4429	5'	120	125
		4430	5'	125	130
		4431	5'	130	135
127-133	Trachite: light grey, fine grained and schistose with minor pyrite	4432	5'	135	140
		4433	5'	140	145
133-145	Trachite: dark grey, fine grained with 15% pyrite				
145	End of Hole				

DRILL HOLE LOG

PROPERTY CONSOLIDATED REXSPAR

HOLE NO. 76-BD-3

LAT. 24,500N)12' S of this

DEP. 23,500E)Location

DIP -89°

AZIMUTH

HOLE STARTED July 30/76

HOLE FINISHED August 3/76

ELEV.

LOGGED BY E. L. Evans

LENGTH 168' SIZE HQ

FOOTAGE	DESCRIPTION
0-36	Casing
36-78	Trachite: light colored, schistose and broken with abundant lemonite
78-80	Trachite: light green schistose
80-103.5	Trachite: dark grey with about 20% pyrite and some fluorite to 88'
103.5-138	Trachite: dark, schistose fragmental with up to 80% pyrite
138-163	Trachite: dark, schistose with some large fragments and fluorite. Pyrite about 50%
1[illegible] 168	Trachite: light grey to green with about 25% pyrite
	END OF HOLE

SAMPLE NO.	LENGTH	From	To		
4434	5'	80	85		
4435	5'	85	90		
4436	5'	90	95		
4437	5'	95	100		
4438	5'	100	105		
4439	5'	105	110		
4440	5'	110	115		
4441	5'	115	120		
4442	5'	120	125		
4443	5'	125	130		
4444	5'	130	135		
4445	5'	135	140		
4446	5'	140	145		
4447	5'	145	150		
4448	5'	150	155		
4449	5'	155	160		
4450	3'	160	163		

DRILL HOLE LOG

PROPERTY CONSOLIDATED REXSPAR — HOLE NO. 76-BD-4

LA- 24525N — DIP -90° — HOLE STARTED August 3/76

DEP. 23370E — AZIMUTH — HOLE FINISHED August 5/76

ELEV. 3450 — LOGGED BY E. L. Evans — LENGTH 107' — SIZE HQ

FOOTAGE	DESCRIPTION	SAMPLE NO.	LENGTH	From	To	U_3O_8
0-32	Casing					
32-54	Trachite: weathered and badly broken	4454	4'	59	63	
		4455	5	63	68)	much core
54-79	Trachite: dark grey, schistose 50% pyrite 62-65 rusted and badly broken 68-69 rusted and badly broken 63-78 much core lost	4456	11'	68	79)	lost
79-89	Trachite: broken and altered and in part contains fault gouge. Represents a fault zone					
89-107	Trachite: dark blue-grey, fine grained with 5% pyrite. Rock cut by numerous fine quartz-filled fractures.					
	END OF HOLE					

KERR–DAWSON & ASSOCIATES LTD. - DIAMOND DRILL RECORD

Suite 1(.19 Victoria St.
Kamloops, B.C.
Phone 374-0544

PROPERTY: REXSPAR, BIRCH ISLAND HOLE No. 76-BD-5

DIP AND AZIMUTH TEST		
	Corrected	
Footage	Angle	Azimuth

Core Size: BQ
Angle of Hole: -60°
Claim:
Section:
Bearing: 90°

Total Depth: 203'
% Recovery: 83%
Elev. Collar: 3310'
Latitude: 24700N
Departure: 23285E

Sheet No 1 of 3
Logged by: W. GRUENWALD
Date Begun: NOV 15/76
Date Finished: NOV 18/76
Core Stored At:

DEPTH	CORE LOST	DESCRIPTION	SAMPLE No.	WIDTH of SAMPLE				
0'-16'		OVERBURDEN OF CLAY AND BOULDERS						
		CASING TO 16'						
16'-24'		GROUND UP BOULDERS + METAVOLCANIC.						
		-last 1' is of a pale green chloritic porphyritic meta-volcanic						
		-phenocrysts (or fragments) ≤1/8".						
		-particles aligned at 70° to C.A.						
		≪1% pyrite ; quartz ≈5%						
		-may be a small metavolcanic capping over the quartz-sericite schist.						
		Radioactivity: Background = 40 cps.						
24'-86'		PALE BROWN TO GRAY QUARTZ SERICITE SCHIST						
	26'	-fine grained and very hard in places - almost cherty						
		-pyrite ≤1%						
		-in places find fair amounts of pale green sericite mica						
		-often quite broken up accounting for loss of some core.						
		-folding of laminae well shown at 82'-86'						
		-74'-86' more massive ; recovered 10' out of 12'						
		-80'-82' pure white quartz with inclusions of green						
		sericite schist (minor pyrite).						

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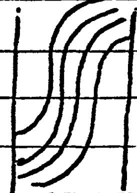
PROPERTY REXSPAR, BIRCH ISLAND HOLE No. 76-BD-5

DEPTH	CORE LOST	DESCRIPTION	SAMPLE No.	WIDTH of SAMPLE				
24'-86'	cont'd.	Core angles:-						
		26'-30°; 30'-75-80°; 33'-65°; 40'-45°; 42'-30°;						
		45'-75°; 53'-65°; 58'-70°; 64'-60°; 70'-55-65°;						
		74'-55°; 78'-30°						
		 folding observed at 82'-86'						
		-bottom of section (86') is rusty and contact is at 50° to C.A.						
		<u>Radioactivity:</u>						
		24'-86' 40-45 c.p.s. -some small areas up to 60 c.p.s. (ie 86').						
86'-203'		PALE GRAY TO GREEN "FRAGMENTAL" TRACHYTE.						
		-fine grained pyrite averages 1-3% (seldom >5%) ie. 195'; 199' pyrite ≥10%.						
	6'	-nearly entire section shows some degree of brecciation.						
		-slight color changes due to variations in amounts of sericite and fluorite (purple).						
		-purple fluorite noted as fragments and bands (1/8"-1") in 89'; 113'-114'; 124'; 125'; 128'; 134'-137'; 178'; 194'; 196-198'.						
		-some late stage feldspar-qtz-fluorite veinlets (1/8"-1/2 thick) observed at 95'; 98'; 99'; 121'; ~~134'-137'; 194'; 196-198'~~						
		-these are generally at 30°-45° to C.A.						
		-134'-137' small section more brecciated than usual; ≈10% pyrite.						
		-the fragments due to later metamorphism show quite often a rough alignment; generally it is 60-80° to the core axis.						
		183'6" - fault, slickensided surfaces; 40° to C.A. displacement is vertical						
		184'6" - fault, good example of pyrite slickensided surface ≈35°-40° to C.A.						

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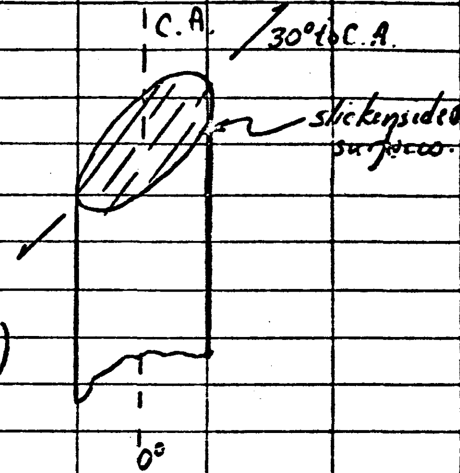
PROPERTY: Rexspar, Birch Island HOLE No. 76-BD-5 SHEET No. 3 of 3

DEPTH	CORE LOST	DESCRIPTION	SAMPLE No.	WIDTH of SAMPLE
86'-203'	cont'd	-203' fault, slickensided pyrite surfaces 30° to C.A		
		nearly vertical displacement		
		-crumpled sections of core at 174'; 176'-177'; 180'; 185'		
		may be small fault zones.		
		Radioactivity:		
		86'-203' Background to 60 c.p.s.		
		average is 40-45 c.p.s. ; locally 60 c.p.s. (ie 102'-103', 120')		
		Photographs i) Box 1(0-75'); Box 2(75'-105'); Box 3(105'-130')		
		ii) Brecciated trachyte close up, Box 3(105-130')		
		iii) Box 4(130'-154'); Box 5(154'-179'); Box 6(179'-203').		
		Overall Recovery is 82%		
		Recovery since 86' is 95%.		



KERR—DAWSON & ASSOCIATES LTD. - DIAMOND DRILL RECORD

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Kamloops, B.C.
Phone 374-0544

PROPERTY REXSPAR, BIRCH ISLAND

HOLE No. 76-BD-6

DIP AND AZIMUTH TEST		
	Corrected	
Footage	Angle	Azimuth

Core Size BQ
Angle of Hole -90°
Claim
Section
Bearing

Total Depth 153'
% Recovery 75-80%
Elev. Collar 3375'
Latitude 24650N
Departure 23290E

Sheet No 1 of 3
Logged by W. GRUENWALD
Date Begun NOV 12/76
Date Finished NOV 14/76
Core Stored At

DEPTH	CORE LOST	DESCRIPTION	SAMPLE No.	WIDTH of SAMPLE				
0'-16'		CASINE IN OVERBURDEN.						
		-overburden to 23'?						
23'-63'	30'	RUSTY BROWN -> GREEN QUARTZ SERICITE SCHIST. (BADLY BROKEN GROUND).						
		-has a laminated appearance with many of the laminae stained						
		by limonite. ; pyrite is approx. 1%.						
		-core angles: 23' 35° . 37' 40° . 41' 70° to 80° to core axis.						
		-57'-63' folded and brecciated (especially at 61'-63').						
		-lower contact is rusted and crumply and at 45-60° to C.A.						
		Radioactivity: BACKGROUND = 45 c.p.s.						
		23'-63' 45-50 c.p.s.						
63-81'		PALE GRAY, MASSIVE, BRECCIATED TRACHYTE						
		-pyrite 3-5%, generally surrounds fragments of trachyte.						
		-purplish color is due to the presence of fine grained purple fluorite						
		-fracturing variable however most are at 30°-45° to C.A.						
		-minor late stage, thin, white feldspar veinlets noted occasionally.						
		Radioactivity:						
		63'-81' 45-55 c.p.s.						

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Phone 374-0544

PROPERTY REXSPAR, BIRCH ISLAND HOLE No. 76-BD-8

DEPTH	CORE LOST	DESCRIPTION	SAMPLE No.	WIDTH of SAMPLE				
81'-98'6"		PALE GRAY-GREEN, MASSIVE, MOTTLED BRECCIATED TRACHYTE.						
		-fine grained pyrite ≤5%, locally 10-15% in small bands.						
		-spotted appearance due to white → gray fragments of trachyte.						
		-fragments obvious at 83'-86'; 93'-98'6"						
		-85'6" small fault showing well developed slickensided surfaces.						
		fault is at 30° to C.A. and movement was horizontal.						
		-large blebs of dark purple fluorite (often with pyrite) at 83'; 85'6"						
		-purple fluorite is also found well disseminated & grains and fragments.						
		-93'-98'6" - lighter colored quite fragmented trachyte showing						
		numerous thin white feldspar ± fluorite-pyrite veinlets (average 60°-70° to C.A.).						
		-streaky appearance is approximately 60-70° to C.A.						
		Radioactivity:						
		81'-98'6" 45-100 c.p.s. (91'-92' 90-100 c.p.s.)						
98'6"-153'		PALE GRAY-GREEN, MASSIVE SECTION OF VARIABLY BRECCIATED TRACHYTE.						
	2'	-section is quite uniform						
End of		-pyrite averages 5% locally up to 7% (last 5' of hole ≈2-3% pyrite)						
Hole.		-section is variably brecciated accounting for differences in mottled appearance						
		-some parts of brecciated zone shows alignment of fragments						
		most common angles of alignment are 68-80° to C.A. (see 101'6"; 110'; 115';						
		123'; 130'; 147')						
		-small bands of massive fluorite (±pyrite) generally 1"-2" thick are						
		found throughout the section.						
		-breccia fragments easily observed at 107'-110'; 117'; 133'-134'; 136'-138';						
		149'; 151'-153'.						
		-late stage white feldspar veinlets (≤1/8") are quite numerous and generally						
		found at 30°-45° to C.A.						

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PROPERTY: Rexspar, Birch Island HOLE No. 76-BD-6 SHEET No. 3 of 3

DEPTH	CORE LOST	DESCRIPTION	SAMPLE No.	WIDTH of SAMPLE				
98'6"-153' cont'd.								
		Radioactivity:						
		98'6"-153' 45'-75 c.p.s.						
		75 c.p.s. at 102'; 80 c.p.s. at 103'; 75 c.p.s. at 148'						
		Photographs.						
		Photo 1 Box 1 (0-77'); Box 2 (77'-101'); Box 3 (101'-125')						
		" 2 Box 3 (101'-125'); Box 4 (125'-150'); Box 5 (150-153').						

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PROPERTY REXSPAR, BIRCH ISLAND HOLE No. 76-BD-1

DIP AND AZIMUTH TEST		
	Corrected	
Footage	Angle	Azimuth

Core Size BQ
Angle of Hole -66°
Claim
Section
Bearing 270°

Total Depth 150'
% Recovery 50%.
Elev. Collar 3420'
Latitude 24550
Departure 23325

Sheet No 1 of 3
Logged by W. GRUENWALD
Date Begun Nov 8/76
Date Finished Nov 10/76
Core Stored At

DEPTH	CORE LOST	DESCRIPTION	SAMPLE No.	WIDTH of SAMPLE				
0-20'		CASING IN OVERBURDEN OF CLAY AND BOULDERS.						
20'-23'6"		VARIOUS ROCK TYPES (OVERBURDEN).						
		-may be subparalleling bedrock.						
		-some of rock types present are:-						
		i) pale brown qtz-sericite schist						
		ii) green metavolcanic (andesitic).						
		iii) qtz monzonite → granite.						
		iv) fragmental trachyte						
		-some of these fragments are waterworn pebbles, therefore						
		bedrock has not been penetrated.						
		-NOTE: RODS becoming quite tight due to squeezing ground						
		-last 1' section is a gneissic, banded chloritic rock with						
		banding 30° to core axis.						
		-This is probably start of bedrock. (or large boulder?)						
23'6"-91'		PALE BROWN, FINE GRAINED, CONTORTED, BRECCIATED QTZ-SERICITE SCHIST.						
	13'	-pyrite ≤1%, rusty fractures due to subsurface water circulation.						
		-bands of massive cherty material interbedded with the schist						
		-core angles variable; many are at 45° to C.A.						
		-Radioactivity; BACKGROUND = 50c.p.s.						
		23'6"-91' Background to 65c.p.s.						

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PROPERTY REXSPAR, BIRCH ISLAND HOLE No. 76-BD-7 SHEET No. 2 of 3

DEPTH	CORE LOST	DESCRIPTION	SAMPLE No.	WIDTH of SAMPLE				
91'-95'6"	1.5'	PALE BROWN - GRAY FRACTURED, CONTORTED QUARTZ-SERICITE SCHIST GRADING DOWN TO TRACHYTE.						
		-pyrite ≤10%						
		-appear well brecciated at 93'-94'						
		-angles of rusty coated fractures = 30 ->45° to C.A.						
		-purple fluorite grains and staining.						
		Radioactivity:						
		91'-95'6" 60-120 c.p.s.						
95'6"-116'	6'	PALE GREEN to GRAY BRECCIATED TRACHYTE (±SERICITE SCHIST) MODERATELY RADIOACTIVE.						
		-pyrite ≤5%; locally up to 50%.						
		-core angles of rusty fractures = 30°-60° to C.A.						
		-96'-99' fairly massive pyrite zone (moderate ->strongly radioactive)						
		-sericite noted as fragments and on fracture faces as a thin film.						
		-becoming more of a trachyte at 100' onward ->						
		-fragments of purple fluorite noted amongst other fragments.						
		-pale green torbernite noted on fractures at 104'-106'						
		-occasional feldspar-qtz-fluorite veinlets noted						
		Radioactivity:						
		95'6"-99' 120-400 c.p.s. (massive pyrite section).						
		99'-116' 50-75 c.p.s. (114'6" 110 c.p.s.).						
116'-142'	3'	DARK GRAY PYRITE-URANINITE REPLACEMENT (BRECCIATED).						
		-pyrite in fine grains and clots, 15-20% locally 50%.						
		-remainder of zone is f.g. black material (uraninite, trachyte? etc).						
		-zone shows brecciation well developed in places						
		-sericite schist (green) fragments found locally in the massive pyrite zone.						

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PROPERTY: Rexspar, Birch Island   HOLE No. 76-BD-7

DEPTH	CORE LOST	DESCRIPTION	SAMPLE No.	WIDTH of SAMPLE				
116-142	cont'd.	-dusky purple fluorite found as fragments and small grains.						
		-fractures are well oxidized to brown and yellow (some may be Uranium alteration minerals)						
		-pyrite grains have a streaked appearance, the orientation of which varies from 0°-30° to C.A. (20°-30° at 130'-133').						
		-upper contact at approximately 60° to C.A.						
		-lower contact at approximately 55° to C.A.						
		Radioactivity:						
		116'-120' 60 c.p.s. -150 c.p.s.						
		120'-128' 200-400 c.p.s.						
		128'-142' 200-450 c.p.s.						
142'-143'		PALE GREEN-BROWN, RUSTY, BRECCIATED QTZ-SERICITE SCHIST + TRACHYTE.						
		-pyrite 5-7%						
		-143' fractures ~~at~~ are steep (20°-30° to C.A.).						
		-fractures are rusty coated.						
		Radioactivity:						
		142'-143 100-175 c.p.s.						
143'-150'		BROKEN SECTION -DRILLING PROBLEMS -LOST MOST CORE.						
	6'	-some of fragments consist of pyrite-uraninite replacement in trachyte indicating the ore zone was not completely intersected.						
End of Hole		-risk of losing hole stopped any further drilling.						
		Photographs. 1 of Box 1 (0-101'); Box 2 (101'-128'); Box 3 (128'-150').						

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KERR-DAWSON & ASSOCIATES LTD. - DIAMOND DRILL RECORD

PROPERTY REXSPAR, BIRCH ISLAND HOLE No. 76-BD-8

DIP AND AZIMUTH TEST		
	Corrected	
Footage	Angle	Azimuth

Core Size BQ
Angle of Hole -90°
Claim
Section
Bearing

Total Depth 126'
% Recovery 82%
Elev. Collar 3440'
Latitude 24250N
Departure 23315E

Sheet No 1 of 4
Logged by W. GRUENWALD
Date Begun NOV 6/76
Date Finished NOV 8/76
Core Stored At

DEPTH	CORE LOST	DESCRIPTION	SAMPLE No.	WIDTH of SAMPLE				
0-16'		CASING IN OVERBURDEN (BOULDERS → CLAY).						
16'-23'	5'	SUBSURFACE BROKEN MICA-PYRITE REPLACEMENT (+URANINITE)						
		-coarse grained grey mica + pyrite replacing a sericite schist -trachyte rock.						
		-banding of pyrite in last 1' is at 60-70° to core axis						
		-pyrite averages ≤10%; locally 15%						
		Radioactivity - 40-50 c.p.s = Background						
		16'-23' 100-150 c.p.s.						
23'-36'	6'	VARIABLY REPLACED TRACHYTE						
		-irregular replacement by pyrite and minor mica.						
		-some pyrite banding noted @ 60° to C.A.						
		-pyrite averages 15%; locally 50%						
		-some sections of pyrite show oxidation to limonite						
		-purple fluorite stained at 25'						
		Radioactivity						
		23'-36' 50-100 c.p.s. (average = 50-60 c.p.s.)						

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PROPERTY: Rexspar, Birch Island HOLE No. 76-BD-8

DEPTH	CORE LOST	DESCRIPTION	SAMPLE No.	WIDTH of SAMPLE				
36'-43'		Massive Pyrite-Magnetite Replacement.						
		-f.g. to med. grained pyrite averages 30-40%, locally 60%.						
		-contains numerous limonite filled cavities.						
		-pyrite is well banded with dips @ 60-70° to C.A.						
		-pale green f.g. sericite schist found parallel to the pyrite banding						
		-magnetite is found throughout the section - up to 2%.						
		-this section averages weak to moderate in magnetism, whereas						
		massive pyrite-mica-uraninite replacements generally lack magnetism.						
		Radioactivity:						
		36'-43' 50-60 c.p.s.						
43'-53'	3'	Variably Radioactive Section of Trachyte.						
		43'-46'6" sericite schist-pyrite-uraninite zone.						
		some trachytic fragments.						
		banding of schist & pyrite is indistinct @ 60-80° to C.A.						
		-pyrite averages 5-10%.						
		46'6" rusty fractured section (6").						
		rock below is a weathered brecciated trachyte - may be						
		small fault ≈ 70° to C.A.						
		purple fluorite staining is present.						
		-last 3-4' is broken, rusty weathering white to grey trachyte						
		Radioactivity:						
		43'-53' 50-100 c.p.s. (100 c.p.s. at 50' ± 1').						

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PROPERTY: REXSPAR, BIRCH ISLAND HOLE No. 76-BD-8

DEPTH	CORE LOST	DESCRIPTION	SAMPLE No.	WIDTH of SAMPLE				
53'-71'	1'	MASSIVE PALE GRAY TRACHYTE.						
		-purplish tint is due to presence of fluorite dispersed						
		through the trachyte.						
		-pyrite content averages <5%, most pyrite found as						
		grains or lenses around fragments of trachyte and sericite schist.						
		-fragments may indicate prior brecciation which has been						
		rehealed so fragmentation isn't definitely obvious throughout the section.						
		-fragmentation is best observed at 64'-66'. fragments consist of trachyte,						
		pale green sericite schist and some feldspar porphyry.						
		dip of zone outlined by fragments and lenses of pyrite is @ 60° to C.A.						
		-some fractures in this section are at 35° to C.A.						
		-very thin & white veinlets of feldspar-qtz cut this section at various angles.						
		Radioactivity:						
		53'-71' 40-50 c.p.s. = Background.						
71'-75'6"		Similar to above except much richer in f.g. pale green						
		sericite schist						
		-pyrite is ≤1%						
		-appears fragmented and rehealed.						
		-rusty fractures noted at 10-35° to C.A.						
		Radioactivity:						
		71'-75'6" 50 c.p.s.						

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PROPERTY Rexspar, Birch Island HOLE No. 76-BD-8 SHEET No. 4 of 4

DEPTH	CORE LOST	DESCRIPTION	SAMPLE No.	WIDTH of SAMPLE				
75'6"-95'	1'	MASSIVE PALE GRAY-GREEN TRACHYTE.						
		-pyrite averages 1-3% (87'-103' up to ≥3%).						
		-purplish stain due to scattered fluorite						
		-fragmental in places though not obvious						
		-core angles noted are 68° to 90° to core axis.						
		Radioactivity:						
		75'6"-95' 50-60 c.p.s. (150 c.p.s at 90').						
95'-105'		MASSIVE PALE GRAY MOTTLED (FRAGMENTAL) TRACHYTE.						
		pyrite 1-3%, found around fragments.						
		sericite partings noted						
		-purple -> gray fluorite still noted as specks and in late veinlets and fractures.						
		Radioactivity: 40-50 c.p.s. = Background.						
		95'-103' 50-60 c.p.s.						
103'-126' End.		MASSIVE PALE GRAY (PURPLISH) TRACHYTE.						
		1-2% pyrite						
		-fragmental in places as above sections.						
		-white feldspar-fluorite-pyrite gash veins at 115'-117'; 119'. Minor specks of galena at 115'.						
		Radioactivity:						
		103'-111' 50-60 c.p.s.	Photo #3	Box 1 (0-57'); Box 2 (57'-87')				
		111'-126' 40-55 c.p.s.	Photo #4	Box 3 (87'-111'); Box 4 (111'-126')				

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PROPERTY: Rexspar, Birch Island

HOLE No. 76-BD-9

DIP AND AZIMUTH TEST		
	Corrected	
Footage	Angle	Azimuth

Core Size: BQ
Angle of Hole: -88°
Claim:
Section:
Bearing: 090°

Total Depth: 126'
% Recovery: 95%
Elev. Collar: 3520'
Latitude: 24250 N
Departure: 23440E

Sheet No 1 of 4
Logged by: W. Gruenwald
Date Begun: No 13/76
Date Finished: No 15/76
Core Stored At:

DEPTH	CORE LOST	DESCRIPTION	SAMPLE No.	WIDTH of SAMPLE				
0-8'		Casing: Overburden 4-5'. Casing in subsurface						
		mineralized zone (4'-8')						
8'-25'6"		Uraniferous Mica-Pyrite Replacement.						
		-coarse grained books of silvery mica						
		-fine grained pyrite and remnants of unreplaced						
		trachyte compose this zone.						
		-pyrite is less than 10%; locally up to 40%						
		-pyrite often in irregular bands.						
		21'-25'6" pale grey porphyritic "trachyte" with						
		white laths of feldspar (4-5mm across).						
		contact with above mineralized zone is irregular at 45° to C.A.						
		minor purple fluorite noted.						
		Radioactivity: 40-50 is Background.						
		8'-20' 90-100 c.p.s.						
		20'-23' 50-60 c.p.s.						
		23'-25' 90-110 c.p.s.						
25'6"-43'6"		Mica-Pyrite-Uraninite Replacement Zone						
		-coarse grained mica (2-8mm across) forms ≥60% of rock						
		-medium grained pyrite, 7-15%						
		-occasional grey f.g. sericite schist beds 10-15%						

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PROPERTY: Rexspar, Birch Island   HOLE No. 76-BD-9

DEPTH	CORE LOST	DESCRIPTION	SAMPLE No.	WIDTH of SAMPLE				
25'6"-	cont'd.							
43'6"		flecks of deep purple fluorite noted in small amounts.						
		41'6" - 6" of pale grey porphyritic trachyte.						
		- dips shown by lines of pyrite & sericite schist						
		are generally 70-90° to the core axis (C.A).						
		42'6 - 43'6" - small zone of mica-pyrite replacement.						
		Radioactivity: 40-50 c.ps. = Background						
		25'-35' 110-340 c.p.s. (≥200 c.p.s at 27', 29', 31')						
		35' - 43'6" 60-90 c.p.s.						
43'6"-		PYRITIC BRECCIATED TRACHYTE.						
63'6"		- fragments of porphyritic trachyte vary from ½cm - 4cm across.						
		- pale green f.g. sericite schist also noted however these						
		are not as common as the above fragments.						
		- fragments are only slightly mineralized by f.g. pyrite						
		- most of pyrite - mica & uranium mineralization is						
		concentrated in the spaces between fragments and						
		in small massive replacement bands.						
		- such well mineralized areas are found at 47'-48'6";						
		50'; 51'; 53'-54', 54'6".						
		- av. pyrite content is ≤10%; locally higher as above.						
		- banding is 70°-85° to the core axis.						
		- occasional qtz-feldspar fluorite blebs at 60', & 63'6".						
		Radioactivity.						
		43'6" - 52' 60-110 c.p.s. (≥100 at 44'-45')						
		52' - 63'6" 50-70 c.p.s.						

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PROPERTY: Rexspar, Birch Island   HOLE No. 76-BD-9   SHEET No. 3 of 4

DEPTH	CORE LOST	DESCRIPTION	SAMPLE No.	WIDTH of SAMPLE				
63'6"-111'		PALE GREEN GRAY TRACHYTE ZONE -slightly brecciated trachyte with pyrite-mica replacement fillings -pyrite is fine grained and overall ≤5% -fragments of pale green sericite schist still noted and seldom are mineralized by pyrite. -coarse grained mica and pyrite replacements are scattered in bands generally 0.5 to 2cm thick. -white feldspar-fluorite-pyrite veins at 64'6"-65'6"; 73'; 90' (also noted galena grains); 98'. 105'-107' mottled white and gray feldspar-sericite-trachyte zone having a striped appearance. -schistosity is 75°-90° to C.A. pyrite 1-2% in this small section with minor galena grains also present. Radioactivity:- 40-50 c.p.s = Background 63'6"-66' 50 c.p.s. 66'-91' 50-60 c.p.s. (75'-76'6" - 75-80 c.p.s) (90' 70-80 c.p.s.) 91'-95' 50±-70 c.p.s 95'-111' 40-50 c.p.s. = Background.						
113'-116'		GRAY, BRECCIATED ZONE. consists of black f.g. fragments (argillite?) 2mm to 2cm across. -pyrite is found with filling in spaces between fragments - averages ≤2% (considering feldspar etc. mica).						

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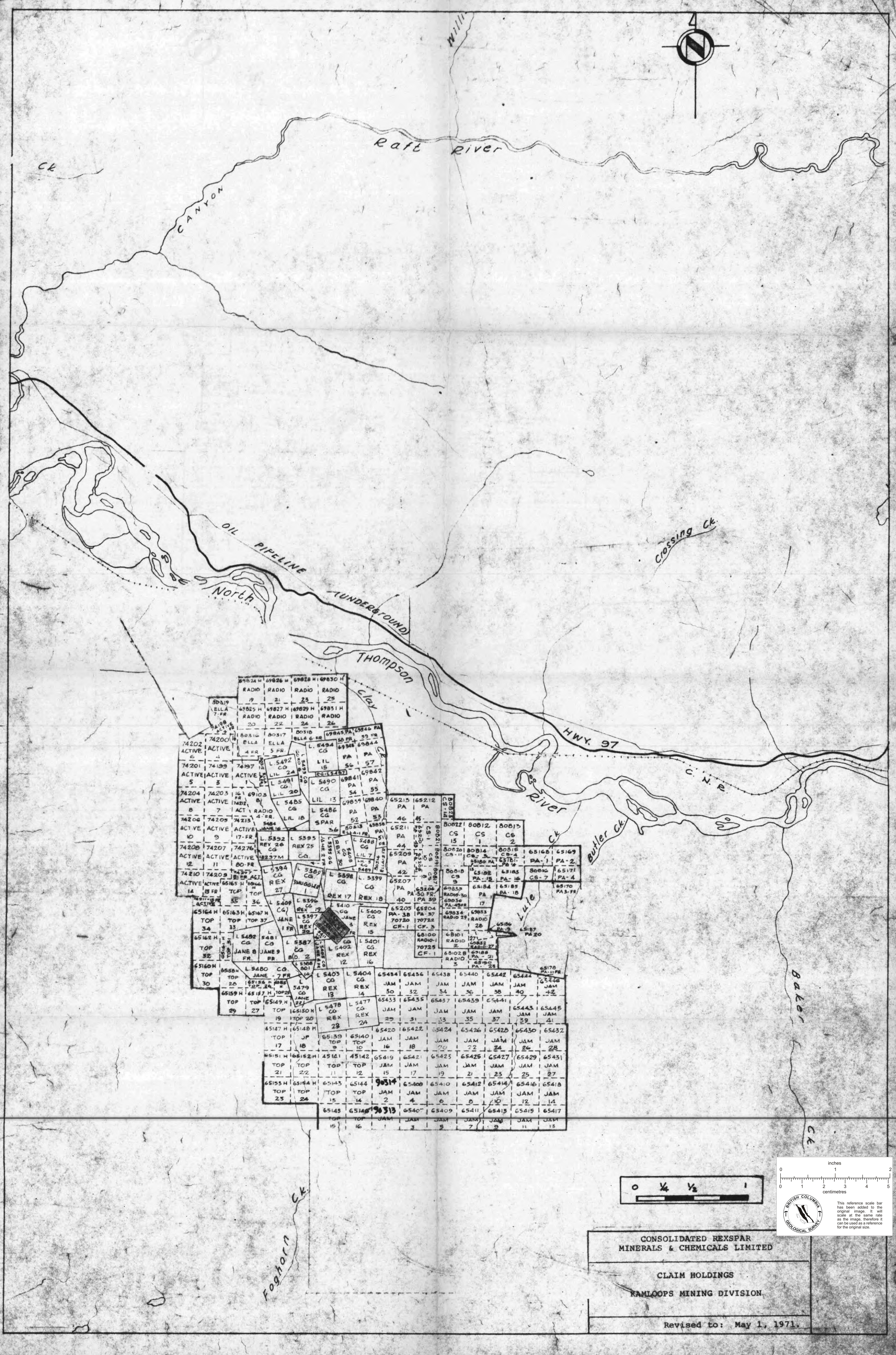
PROPERTY Rexspar HOLE No. 76-BD-9 SHEET No. 4 of 4

DEPTH	CORE LOST	DESCRIPTION	SAMPLE No.	WIDTH of SAMPLE				
113-116'	cont'd.	Radioactivity:-						
		113'-114' 70-80 c.p.s.						
		114'-116 40-50 c.p.s. (Background).						
116'-126'		GREEN GRAY WEAKLY MINERALIZED TRACHYTE (WEAKLY RADIOACTIVE)						
		-brecciation is well developed in places.						
		-some of fragments are partially or wholly composed of fluorite						
		-sericite schist fragments & bands also noted.						
		-pyrite is generally f.g. and found in spaces between fragments. -av. content is ≤ 5%						
		-brecciation is generally coarse (i.e. large fragments).						
		Radioactivity:						
		116'-126' 50-140 c.p.s. (Highest 116' 100 c.p.s. / 122' 100 c.p.s. / 125' 140 c.p.s.)						
		Photo #1 Box 1 (0-42') ; Box 2 (42'-66')						
		Photo #2 Box 3 (66'-91') ; Box 4 (91'-116') ; Box 5 (116'-126').						



Raft River
CANYON
Ck
OIL PIPELINE (UNDERGROUND)
North
Thompson
River
Clay Ck
HWY. 97
C. N. R.
Crossing Ck.
Butler Ck.
Lute Ck
Baker Ck
Foghorn Ck.
0 1/4 1/2 1
CONSOLIDATED REXSPAR
MINERALS & CHEMICALS LIMITED
CLAIM HOLDINGS
KAMLOOPS MINING DIVISION
Revised to: May 1, 1971.
inches
centimetres
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.
BRITISH COLUMBIA GEOLOGICAL SURVEY


REX 19
REX 20
JANE 3 FR
SPAR 1
SPAR 2
LIL 39 FR.
BLACK DIAMOND 2
JANE 4 FR.
REX 12
Underground workings
Ore Outline
Pit Limit
LEGEND
ROAD
CONTOUR INTERVALS - 50'
D.D. HOLE - VERTICAL
- INCLINED
CLAIM BOUNDARY
UNDERGROUND WORKINGS - VERTICAL PROJECTION
75-2 DRILL HOLES 1975
76A-5 DRILL HOLES 1976
CROWN GRANTED MINERAL CLAIMS
1. Fluorite Zone
2. "A" Zone
3. "BD" Zone
4. "B" Zone
5. "H" Zone
CONSOLIDATED REXSPAR
MINERALS AND CHEMICALS, LTD.
BIRCH ISLAND, B.C.
MINERALIZED ZONES
SURFACE DIAMOND DRILL HOLES
200 150 100 50 0 100 200
Feet
SCALE: 1" = 100'
N.T.S. REF. 82 M 12
DRAWN BY: J. van Kralingen
DATE: November, 1972
NOTE: Drill Hole locations taken from original Diamond Drilling Logs
REVISIONS: March, 1973
MARCH, 1976
OCT., 1976