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METALLURGICAL REPORT

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REXSPAR URANIUM & METALS MINING CO. LIMITED

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Section 1

GENERAL MINERALOGY

The ore is a fine-grained siliceous rock consisting mainly of feldspar and mica. Abundant pyrite and considerable fluorite is present. Small amounts of rutile, bastnasite, apatite, siderite and celestite also occur.

The uranium bearing minerals are very fine-grained uranothorite, pitchblends, uraninite, and metatorbernite. Monazite and allanite are also reported to occur in the ore. A large proportion of the radioactive constituents occurs in intimate intergrowths with rutile and is very finely disseminated in gangue.

METALLURGICAL TESTWORK

From 1951 to 1956, laboratory metallurgical studies were conducted at various periods at the Radioactivity Division, Department of Mines and Technical Surveys, Ottawa: and also in the Department of Mining and Metallurgy of the University of British Columbia under the direction of Professor F. A. Forward.

This testwork showed that the ore does not respond to the conventional acid or carbonate leaching methods, both of which yield maximum extractions of only 50 - 60% of the U_3O_8 .

On the other hand, the acid-pressure leach process developed at the University of British Columbia has yielded extractions exceeding 90%. The substantially higher recoveries which this method affords over the other leaching procedures appear to be the result of the higher temperatures and pressures which it employs. The method is characterized by a number of further advantageous features such as the relatively short retention time which is required, and the low leaching reagent cost resulting from the fact that only water and air/used in the leach, the necessary acid being generated during the operation from the sulphides already present in the ore.

The basic work on the application of this leaching technique to the Rexspar ore is summarized in the two following reports from the Department of Mining and Metallurgy, University of British Columbia.

Report on Laboratory Investigations by F. A. Forward, J. Halpern, November 1st, 1953.

Laboratory Investigation of Treatment of Rexspar Uranium Ore
Final Report by J. Halpern, August 15th, 1955.

During the latter part of 1956, bulk samples of mine ore were shipped to the Radioactivity Division, Department of Mines and Technical Surveys, Ottawa, for further laboratory investigational work with the acid-pressure leach process. As well as the development of leach plant design data, this work was directed toward finding the most applicable method of recovering uranium from leach liquor to a final product that would meet shipping specifications.

In October and November 1956, Battelle Memorial Institute were asked to review and report on the various aspects of the metallurgical programme.

During the period January 29th - February 22nd, 1957, approximately 12 tons of bulk underground ore were processed in a small pilot plant leach tower at the plant of Sherritt Gordon Mines Limited, Fort Saskatchewan, Alberta. The duration of the pilot plant/was approximately three weeks. Uranium bearing liquor from the run was shipped to the Radioactivity Division, Department of Mines and Technical Surveys, Ottawa.

During the period January - April 1958, a pilot plant leaching tower was erected and operated at the Radioactivity Division, Department of Mines and Technical Surveys, Ottawa. Approximately 10 tons of bulk underground ore from the A and BD zones were sent to Ottawa for this work. The primary purposes of the additional testwork were to obtain further data on the following subjects.

- (a) Materials of construction for the leaching towers from the stand-points of corrosion and erosion.
- (b) Design and operating factors re thickening and filtration of acid leach pulps.
- (c) Solvent extraction performance and the recovery of uranium product conforming to the Eldorado contract specifications.

RESULTS OF METALLURGICAL TESTWORK

The work performed by the various group mentioned above has been reported as follows:

Letter of November 29th, 1956 from Battelle Memorial Institute
Report of April 9th, 1957 from Sherritt Gordon Mines Limited.

The following reports have been received from the Radioactivity Division, Department of Mines and Technical Surveys, Ottawa.

SR 468/57 - March 29/57.
SR 475/57 - May 21/57
SR 476/57 - May 29/57

The following conclusions are available from the Sherritt Gordon report of April 9th, 1957:

- (a) Uranium extractions of 93-95% were consistently obtained in batch runs under the conditions that had been suggested on the basis of prior laboratory studies.
- (b) Corrosion and erosion were indicated to be severe; however it is important to note that the duration of the run was too short to allow definite conclusions on corrosion to be drawn.

The investigational work conducted at the Department of Mines, Ottawa subsequently has shown the following:

- (a) Satisfactory performance was obtained during the test period with a number of materials of construction that had been chosen for test purposes as tower linings, pipe, fittings, etc. in the leaching section of the plant; however the length of the pilot plant work was too short to allow final conclusions on corrosion to be drawn.
- (b) A solvent extraction process is the preferred method of recovering uranium from leach liquors; and results with this technique are reported to be satisfactory.
- (c) The design factors for all major operations in the flowsheet are within the limits that are considered normal for the uranium industry; however because of point 3 immediately below, this statement does not apply to the leaching step.

General Status of Plant Engineering

The following points are pertinent in considering in a general way the status of Rexspar engineering efforts:

1. Towers of the size which is contemplated for leaching activities have not yet been used in continuous full scale plant operation.
2. Similar general types of leaching techniques have been put into operation in the United States in recent years.
3. This project will represent the first plant scale application of the acid-pressure leach process in the uranium field.
4. Five solvent extraction plants are now in successful operation in the uranium raw material field in the United States; and additional units are in various stages of design and construction.

Eldorado Mining and Refining Limited brought a solvent extraction plant into operation at their mine at Port Radium, N.W.T. in February 1958.

Evaluation of Risk in Milling Operations

As is the case with the initial establishment of any new metallurgical process, it must be pointed out that there is some degree of risk involved in proceeding to full scale operation; and the evaluation of the risk involved becomes a matter of opinion based on experience.

The following quotation from their letter report of November 29th, 1956 summarizes the views of the Battelle Memorial Institute on the degree of the risk involved on this project.

"The process as envisaged is relatively simple, and Battelle believes that there is now enough know-how available in the field of pressure hydro-metallurgy so Rexspar would have a good chance of constructing a successful full-scale plant using this process without the necessity of doing extensive pilot work. This statement is based on the assumption that the experience of Sherritt Gordon Mines and others in the field will be available to Rexspar. This previous experience and know-how is absolutely essential to avoid failure."

The above comment was made by Battelle prior to the pilot plant work at Fort Saskatchewan and Ottawa in January - February 1957 and January - April 1958 respectively. Although limited in duration, the laboratory and pilot plant work has been satisfactory from the standpoints of metallurgy and equipment engineering.

For plant design activities, Rexspar will have available some of the most experienced and successful organizations in this field of hydro-metallurgy. These include the engineering staff of Sherritt Gordon Mines Ltd., United Engineers and Constructors Inc., Professor F. A. Forward and A. H. Ross and Associates.

The opinions and advice of the staff of Sherritt Gordon Mines Limited have been accepted in interpreting the leach test results and in the preparation of the leach section of the flowsheet from an engineering standpoint.

It is our opinion that to some extent, the initial six months of operation of the plant must be considered to be a development period required to finalize the details of various phases of engineering design and metallurgy; and that the somewhat higher operating costs and lower recoveries of uranium must be anticipated throughout the life of the Eldorado contract than would normally be the case. We have endeavored to place an economic evaluation on these matters by using the following factors in our estimates of production, operating costs and uranium recoveries.

- (a) Tonnage treated during the first six months of mill operation will only average about 70% of nominal full design tonnage; and unit operating costs during this period will be 18% higher than the /about average during subsequent years.
- (b) In order to reflect the anticipated higher cost in the grinding section, mill maintenance has been estimated at \$0.75 per ton, whereas a maximum of about \$0.50 per ton is normally used by ourselves in estimated operating costs of other uranium projects in Canada and the United States.
- (c) In estimating the overall recovery of uranium, a conservative interpretation has been placed upon test results.

The technical risks that exist in the Rexspar program are similar to those encountered and eventually overcome in other operations of a like nature in the last few years. It is our opinion that Rexspar would also find the possible technical difficulties to be surmountable, as has been the case in these other operations.

SECTION 2

Scope of Studies

A copy of the contract No. PH-RX-113 dated January 14, 1957 from Eldorado Mining & Refining Limited to Rexspar Uranium & Metals Mining Co. Limited, has been available for these studies.

For the preparation of this report, quotations have been available from reputable suppliers on the cost of virtually all major operating supplies, power and chemicals. In the few remaining cases, unit costs have been verified by other means.

Capital Costs

The selected method of treatment may be described as an acid pressure leach-solvent extraction flowsheet.

Adequate facilities have been planned for the receipt, storage and distribution of supplies and chemicals.

Wright Engineers Limited, Vancouver, have been engaged to design the crushing plant, grinding section and all service facilities; Ball, Craig, Short & Company Limited, Toronto, are the design engineers of the leaching-solvent extraction - final uranium product sections of the mill.

Many engineering details are not yet finalized.

In our opinion, the consulting design engineers are competent for their responsibilities on this project.

Separate estimates of capital costs have been prepared by Wright Engineers Limited and Ball, Craig, Short & Company Limited for an operation having a nominal rated capacity of 1,100 tons per day under stabilized conditions.

Power Supply

Rexspar has signed a contract with the British Columbia Power Commission for the supply of electric power requirements; and construction work on a transmission line to the mine property is now about 33 1/3% completed.

Water Supply

An ample supply of water for process and domestic operations is readily available from the North Thompson River which is 3/4 miles distant from the plant site.

In addition, working capital needed to take care of product inventories is estimated as follows:

	<u>Equivalent tons of ore</u>
Unfinished production in mill inventory	8,000
Finished but unshipped product inventory	16,000
Shipped product inventory for which payment has not been received	22,000

At an applicable mining and milling cost figure of about \$6.20 per ton, working capital needed to provide production inventories is \$285,000.

General -

All of the contents of this report are premised upon proper continued detailed engineering of the flowsheet, together with the provision of an adequate operating staff. Both of these matters are considered to be of primary and major importance.

Yours truly,

A. H. ROSS & ASSOCIATES

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