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CANMET

REPORT 79-26

Canada Centre
for Mineral
and Energy
Technology

Centre canadien
de la technologie
des minéraux
et de l'énergie

SUMMARIES OF CANMET RESEARCH CONTRACTS 1978-1979

COMPILED BY D.C. MISENER

ENERGY AND MINERALS RESEARCH PROGRAMS
RESEARCH PROGRAM OFFICE



Energy, Mines and
Resources Canada

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DECEMBER 1979

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Compiled by

D.C. Misener*

CANMET REPORT 79-26

*Contract administrator, Research Program Office, CANMET, Energy, Mines and Resources Canada, Ottawa.

FOREWORD

In accordance with Federal government policy, contracting-out continues to play an important role in CANMET research. During fiscal year 1979-80, approximately \$3 500 000 was spent on Energy Program contracts, and \$1 000 000 on Minerals Program contracts, together representing more than 15% of the total branch budget. It is expected that this proportion will increase to almost 20% during fiscal year 1980-81.

CANMET R & D is organized in a program-activity structure in which there are two main programs - Energy Research and Minerals Research, each with several activities. Summaries in this report are arranged according to this structure. The purpose of the report is to inform both the public and private sectors about technology stemming from CANMET's contracting-out policy. The supporting documents referred to in the summaries are available from Micromedia Limited, 144 Front Street West, Toronto, Ontario, M5J 1G2, Tel: (416) 593-5211; Telex: 065-24668.

D.C. Misener

Contracts Administrator

AVANT-PROPOS

En accord avec la politique du gouvernement Fédéral, l'octroi de contrat continu à jouer un rôle important quand à la recherche effectuée au CANMET. Durant l'année fiscale budgétaire 1979-80, approximativement \$3 500 000 ont été dépensés en contrats pour le Programme de l'Energie, et \$1 000 000 en contrats pour le Programme des Minéraux, le tout représentant plus de 15% du budget total de la division. On prévoit la hausse de cette proportion jusqu'à près de 20% au cours de l'année fiscale budgétaire 1980-81.

CANMET R&D est organisé en une structure programme-fonction dans laquelle se trouve deux programmes principaux - Recherche Énergétique et Recherche Minière, chacun contenant plusieurs activités. Les résumés du rapport qui suit sont disposés selon cette structure. Ce rapport a pour but d'informer les secteurs publiques et privés en ce qui concerne la technologie issue de la politique de l'octroi de contrat du CANMET. Les pièces à l'appui auxquelles réfèrent les résumés sont disponibles chez Micromedia Limited, 144 Rue Front Ouest, Toronto, Ontario, M5J 1G2, Tel: (416) 593-5211; Telex: 065-24668.

D.C. Misener

Administrateur des contrats

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ENERGY PROGRAM

CONSERVATION

TITLE: Design, development and prototype of a heat reclaimer	FUNDING CANMET: 57 315.00	PROGRAM: Energy ACTIVITY: Technology Devel.
CONTRACTOR: Cambrian Engineering	CONTRACTOR:	
SCIENTIFIC AUTHORITY: T.D. Brown	DSS:	SUB-ACTIVITY: Conservation
TEL: 996-4570 Ext 219	OTHER:	SUB-SUB-ACTIVITY: Oil and gas Combustion
BEGIN/END: Sept. 1977 - Feb. 1979		
REQUISITION NO.: 23440-6-9089	TOTAL: \$57 315.00	PROJECT:

OBJECTIVES (by task)

1. To generate a conceptual design for a proposed heat reclaimer of optimum configuration,
2. to carry out design calculations for the conceptual design,
3. to produce manufacturing drawings and material specifications for proposed heat reclaimer,
4. to specify a control system for the proposed heat reclaimer,
5. to carry out an analysis of production costs for an initial run of 10 000 units,
6. to produce two prototype units, including controls for performance evaluation at Canadian Combustion Research Laboratory (CCRL).

PROCEDURE

- a. Computer analysis of finned-pipe heat transfer characteristics in heat pipe applications.
- b. Experimental verification of computer generated design on laboratory prototype.
- c. Experimental study of self cleaning characteristics of several ceramic coatings.

- d. Generation of final design and material selection.

The above items were documented in Phase I report.

- e. Procurement of materials and construction of two prototype units.
- f. Control system specification - "Off the Shelf" equipment.

RESULTS

The two deliverable items have been received at CCRL.

APPLICATION AND ONGOING WORK

The two prototype units will be evaluated at CCRL to establish their long-term performance characteristics, Cambrian will continue its contract with CSA with a view to manufacturing.

SUPPORTING DOCUMENTS

Phase I report already with contracts office.
Phase II report.

TITLE: Development of an industrial burner	FUNDING	PROGRAM: Energy
for using gases of low calorific value	CANMET: \$85 814.43	ACTIVITY: Technology Devel.
CONTRACTOR: Canadian Gas Research Inst.	CONTRACTOR:	
SCIENTIFIC AUTHORITY: G.K. Lee	DSS:	SUB-ACTIVITY: Conservation
TEL: (613) 996-4570	OTHER:	SUB-SUB-ACTIVITY: Oil and gas
BEGIN/END: April 14/78 - March 15/79		combustion
REQUISITION NO.: 023440-7-9073-U	TOTAL: \$85 814.43	PROJECT:

OBJECTIVES

1. To develop a low pollutant industrial burner capable of utilizing low energy gases of 3.7 - 14.9 MJ/m³ (100 - 400 Btu/cu ft) produced by coal gasification or from biomass sources,
2. to produce criteria for adapting the burner design for different types of fuel in the heating value range of interest,
3. to investigate parameters for using burners in boiler applications.

PROCEDURE

1. Conducted a literature survey and obtained field data to establish information based on low calorific gas compositions and burner designs.
2. Applied earlier CGRI knowledge derived for industrial power burner and construction heaters to the development of a prototype burner.
3. Developed burner design criteria for high-efficiency and low pollution.
4. Developed system to synthesize low calorific gases.
5. Fabricated and assembled prototype burner and firing chamber.
6. Conducted burn trials with various burner designs and fuel compositions.

7. Held seminar at CANMET and received final report.

RESULTS

1. Achieved May 31, 1978
2. Achieved June 30, 1978
3. Achieved July 31, 1979
4. Achieved August 31, 1979
5. Achieved September 30, 1978
6. Achieved January 31, 1979
7. Achieved March 15, 1979

APPLICATION AND ONGOING WORK

Foregoing work led to Phase II which involves scale-up of the prototype burner and gas supply systems and the testing of various burner configurations on synthetic gases. Parameters for designing a full-scale industrial burner are to be defined.

SUPPORTING DOCUMENTS

Progress report on state of art review received July 31, 1978. Final report and microfiche sent to contract office March 31, 1979.

ENERGY PROGRAM

OIL AND GAS

TITLE: Drill test holes in oil sands around tunnel at Ft. McMurray	FUNDING	PROGRAM: Energy
CONTRACTOR: Thurber Consultants Ltd.	CANMET: \$ 21 916.62	ACTIVITY: Technology Devel.
SCIENTIFIC AUTHORITY: V. Srajer	CONTRACTOR:	
TEL: (403) 284-0110	DSS:	SUB-ACTIVITY: Oil and gas
BEGIN/END: Nov. 1978 - Nov. 1978	OTHER:	SUB-SUB-ACTIVITY: Oil sands
REQUISITION NO.: 23440-7-9119	TOTAL: \$21 916.62	PROJECT:

OBJECTIVES

To drill test holes in oil sands along a horizontal radius from the Saline Creek tunnel in Ft. McMurray.

PROCEDURE

The contractor drilled eight holes in three sections, each hole up to 30 m long as directed by the scientific authority (S.A.).

RESULTS

The drill holes were used by S.A. for the air injection test, performed simultaneously on site.

APPLICATION AND ONGOING WORK

The air injection test report will be sent to selected consulting companies for comment.

SUPPORTING DOCUMENTS

None required from contractor.

TITLE: To develop a non-linear model of oil sand behaviour and its application	FUNDING CANMET: \$48 649.44	PROGRAM: Energy ACTIVITY: Res. & Tech. Devel.
CONTRACTOR: Thurber Consultants Ltd.	CONTRACTOR:	
SCIENTIFIC AUTHORITY: Yang S. Yu	DSS:	SUB-ACTIVITY: Oil and gas
TEL: 996-4570 Ext 145	OTHER:	SUB-SUB-ACTIVITY: Oil sands mining
BEGIN/END: Oct. 24/78 - Mar. 15/79		
REQUISITION NO.: 23440-8-9012	TOTAL: \$48 649.44	PROJECT:

OBJECTIVES

The purpose of this contract was to develop a computer model which could be used to predict the deformational behaviour adjacent to mine workings at depth in oil sands.

To model the stress-strain behaviour of oil sands realistically, the computer model should incorporate the following aspect of oil sands:

- non-linear strain-softening behaviour;
- stress-dependent failure criteria;
- the effects of gas evolution, and the effect which temperature and fluid pressure have on gas evolution; and
- the effects of gas drainings on fluid pressure.

PROCEDURE

The following procedures were required to obtain a computer model which would meet the objectives:

- Developed an FE computer program and incorporated all necessary aspects of oil sands;
- the program was coded in machine-independent Fortran; input/output was streamlined, and the program made flexible and user-oriented;
- analyses were carried out of the Saline Creek tunnel and G.C.O.S. test shaft using the program, and the results compared with observed behaviour from the field. Results were then used as a basis for assessing effectiveness of the computer model;
- carried out a primary study to predict stress distribution and support loads for a variety of geometric mining configurations;
- prepared a final report including a user's manual;
- recommended further R & D if warranted in relation to further development of the computer model.

RESULTS

Thurber Consultants Ltd. is a reputable consulting firm in geotechnical engineering experienced in the field of oil sand. Unfortunately, the project team seemed less competent in numerical analysis and had to rely heavily on the subcontractor. This was one of the reasons which caused several months delay. However, most objectives were accomplished except item 4 as described because Thurber's review of its own contract progress indicated that projected costs to completion would exceed authorized funds, and consequently, scope of work was revised in consultation with CANMET program office and DSS.

Copies of the final report plus microfiche were delivered to MRL. Software for the computer program has been transferred to the departmental computer. Limited tests were carried out and results indicated that the program seemed to be working properly.

APPLICATION AND ONGOING WORK

The computer model is a valuable analytical tool which can assist in the designing of shafts, tunnels and other mine workings in oil sands under plane strain conditions.

A number of refinements of this model are suggested. However, the S.A. feels that no further work should be undertaken until enough field data or observations have been collected from oil sand operations.

SUPPORTING DOCUMENTS

"Computer model for stress-strain analysis of oil sand" prepared by Thurber Consultants Ltd.; June 1979.

Microfiche of the same report.
One software (computer program).

TITLE: To investigate geotechnical and mining characteristics of the water- ways formation limestones	FUNDING CANMET: \$ 29 473.70	PROGRAM: Energy ACTIVITY: Res. & Tech. Devel.
CONTRACTOR: Golder Geotechnical Consult.	CONTRACTOR:	
SCIENTIFIC AUTHORITY: V. Srajer	DSS:	SUB-ACTIVITY: Oil and gas
TEL: (413) 284-0385	OTHER:	SUB-SUB-ACTIVITY: Oil sands mining
BEGIN/END: Sept. 15/78 - Mar. 15/79		
REQUISITION NO.: 23440-7-9121	TOTAL: \$ 29 473 70	PROJECT:

OBJECTIVES

To investigate geotechnical and mining characteristics of the Waterways formation limestones.

PROCEDURE

- a. review of literature;
- b. testing of rock samples;
- c. analysis of the test;
- d. review of excavation in limestone elsewhere;
- e. evaluation of underground methods;
- f. assessment of limestone as a raw material.

RESULTS

Presented report on characteristics of Waterways limestones with proposal to use limestones for access to McMurray oil-bearing formation.

APPLICATION AND ONGOING WORK

The work could have significant application in underground mining of oil sands. Technology transfer seminar planned for Dec 10, 1979 in Calgary.

SUPPORTING DOCUMENTS

Report.

TITLE: Mechanical upgrading and solvent extraction of Athabasca oil sands	FUNDING	PROGRAM: Energy Research
CONTRACTOR: University of Toronto	CANMET: \$28 587.00	ACTIVITY: Technology Devel.
SCIENTIFIC AUTHORITY: G.M. Ritcey	CONTRACTOR:	
TEL: (613) 995-4124	DSS: \$72 472.00	SUB-ACTIVITY: Oil and gas
BEGIN/END: July 26/76 - March 31/77	OTHER:	SUB-SUB-ACTIVITY: Bitumen-sand separation
REQUISITION NO.: 23440-6-9007	TOTAL: \$101 059.00	PROJECT:

OBJECTIVES

The project is part of the Energy Research Program to develop technology for treating oil sands. Mechanical upgrading followed by solvent extraction was selected. A literature survey of this treatment, including solvent recovery was required as well as an investigation to determine the necessary operating parameters for releasing the oil and a comparison of spherical agglomeration with solvent extraction. Finally, an economic assessment of the solvent extraction process for recovery of bitumen from oil sands was required.

PROCEDURE

A literature survey was carried out on mechanical upgrading and solvent extraction. Investigations into the efficiency of solvent extraction of bitumen from Athabasca oil sands were performed in laboratory-scale batch stirred vessels. Solvent type, solids concentration, stirrer speed and contact time were investigated. A process flowsheet was proposed for the anhydrous extraction of bitumen from 1.36×10^5 kg/h (3.0×10^5 lb/h) of tar sand. The flowsheet was then used as a basis for an economic and sensitivity analysis of operating costs to investigate the significance of important process parameters such as solvent type, solvent/tar sand ratio and solvent recovery efficiencies.

RESULTS

The literature survey indicated that the current

state of knowledge on the recovery of bitumen from oil sands by mechanical upgrading and by solvent extraction was limited. The agglomeration technique has, to date, resulted in poor performance. Although solvent extraction appears to offer potential, limited data are available and research is required. Studies were carried out on different solvents over a range of operating conditions and a comparison was made related to relative mass transfer coefficients. Agitator speed was demonstrated as an important variable. Above a minimum rate, the mass transfer coefficient increases linearly with stirrer speed. Extraction efficiency also was increased with an increase in solids content. The economic and sensitivity analysis indicated that the solvent/tar sand ratio must be about 0.1 to limit solvent recovery costs. A low boiling point solvent is more economical for cost reduction. An aliphatic solvent is preferred over aromatic.

APPLICATION AND ONGOING WORK

The research and data collected in the 1976-77 fiscal year was sufficiently encouraging to continue the project for a further year.

SUPPORTING DOCUMENTS

1. Literature Review: Mechanical upgrading and solvent extraction of Athabasca oil sands.
2. Parameters and mechanisms in the solvent extraction of Mined Athabasca oil sand.

TITLE: Study on mechanical upgrading and solvent extraction of Athabasca oil sands (continuation)	FUNDING CANMET: \$ 73 000.00	PROGRAM: Energy ACTIVITY: Technology Devel.
CONTRACTOR: University of Toronto	CONTRACTOR:	
SCIENTIFIC AUTHORITY: G.M. Ritcey	DSS:	SUB-ACTIVITY: Oil and gas
TEL: (613) 995-4124	OTHER:	SUB-SUB-ACTIVITY: Bitumen-sand separation
BEGIN/END:		
REQUISITION NO.: 23440-8-9029	TOTAL: \$ 73 000.00	PROJECT:

OBJECTIVES

The project is part of the Energy Research Program to develop technology pertaining to the treatment of oil sands through mechanical upgrading followed by solvent extraction. The program was begun during the 1976-77 fiscal year. After a literature survey the research program required determination of the operating parameters for release of the oil. Finally an economic assessment of the solvent extraction process for recovery of bitumen from oil sands was required.

PROCEDURE

The research comprised three phases:

- 1) mechanical upgrading in rotating contactors;
- 2) solvent extraction of oil sands in rotating contactors;
- 3) recovery of solvent from extracted sands.

RESULTS

Mechanical upgrading

1. Temperatures of 20, 40 and 90°C resulted in recovery of 30, 80 and 90% respectively.
2. An addition of <5% w/w of solvent (from the sands) resulted in increased recovery.
3. Bitumen recovery was increased by addition of 0.2% surfactant.
4. Mechanical upgrading, cold water process, in a rotary contactor 57 cm in internal diameter indicated steady state in 2 h and an 86% up-

graded product obtained with a sand rejection of 99%.

Solvent extraction in rotary contactors

1. Preliminary mass transfer characteristics were studied in a rotating contactor, indicating further work was required to study geometry and lifter height ratio.
2. A mathematical model was developed to characterize solvent extraction in a rotary contactor.

Solvent recovery

1. Solvent recovery from a fixed bed of extracted oil by surfactants indicated best performances of 92% recovery with 0.2% Sulframin AB-40 (of 7 tested). It also gave lowest solvent-aqueous interfacial tension.
2. Recovery efficiency by displacement with toluene increased with increasing flood velocity.
3. Surfactant addition increased recovery.
4. Tests with toluene indicated steam stripping resulted in 98.5% recovery.

APPLICATION AND ONGOING WORK

The work is sufficiently encouraging to continue for a final year - after which time the total research work should be assessed.

SUPPORTING DOCUMENTS

Mechanical upgrading and solvent extraction of Athabaska oil sands.

Modelling and mechanistic studies.

TITLE: Analysis of bitumen processing catalysts by "Electron scattering for chemical analysis" (ESCA)

CONTRACTOR: Univ. of Western Ontario

SCIENTIFIC AUTHORITY: A. Hardin

TEL: 996-4570

BEGIN/END: Nov. 4/77 - Mar. 31/78

REQUISITION NO.: 23440-7-9067

FUNDING

CANMET: \$ 26 125.00

CONTRACTOR:

DSS:

OTHER:

TOTAL: \$26 125.00

PROGRAM: Energy

ACTIVITY: Technology Devel.

SUB-ACTIVITY: Oil and gas

SUB-SUB-ACTIVITY: Catalysis

PROJECT:

OBJECTIVES

Using the ESCA technique to analyze the surface chemistry of a number of hydrodesulphurization and dehydrogenation catalysts. Qualitatively, to identify peaks due to Al, Mo, O, F, Ni, Co, Fe, Si, Ca and S in these catalysts. Quantitatively to obtain surface atomic percentages accurate to within 5%, and to relate those to the bulk atomic percentage where wt % of MoO_3 is small ($\leq 12\%$) compared with the Al_2O_3 support. For higher MoO_3 concentrations, the surface and bulk compositions may differ appreciably. To study several Kejen catalysts and show the Mo concentration on the surface compared with that expected on the basis of their bulk composition.

PROCEDURE

Electrons of preset kinetic energy pass through the analyzer and the exit slit and are detected by an electron multiplier, counted by digital electronics, and stored in a PDP-8E computer. The counting is done for a preset DT (Dwell Time) before the computer changes the analyzer pass energy by a chosen step, DE. Enough scans (NS) were made to increase the signal-to-noise ratio to a desirable level.

Eight samples were mounted on a turret wheel, and the computer was programed to collect the desired spectral range. The geometry of the system was such that low energy secondary electrons emitted from the X-ray window tended to neutralize the sample charging.

Sample degassing was considerable, and the pump down time was usually one day. No spectra were observed during this period.

Samples were normally mounted on the turret as extruded pellets. Some were ground and reformed into a $\sqrt{1/2}$ -mm thick disk. The irregular surfaces

of parallel mounted extruded pellets resulted in considerable electric charging (~ 3 eV), and differential charging. The latter increasing the peak line widths to approximately 3 eV. Pressed disks reduced the charging problem.

RESULTS

Surfaces of 45 hydrodesulphurization catalysts were studied in various forms by Electron Spectroscopy for Chemical Analysis (ESCA) to quantitatively determine their elemental composition and the valence states of each element. Where spectra were taken with high resolution and high signal-to-noise ratio, the quantitative elemental determination has an uncertainty of less than 5%. Bulk chemistry, when known from sample preparation, has been found to be in good agreement with the surface chemistry determined by ESCA. The calculated correlation coefficients between bulk and surface compositions have values greater than 0.97.

Sample charging effects are the most detrimental factors in the analysis. The effect is small when the samples are specially formed. The carbon contamination of the catalyst due to vacuum pump oil is insignificant.

With the information presented and by taking good ESCA spectra of selected samples in special forms, it is possible to analyze which of the various models of catalyst surface composition agrees with the ESCA findings.

APPLICATION AND ONGOING WORK

Overall, results strongly suggest that ESCA is an excellent routine quantitative method for elemental analysis of such catalysts.

SUPPORTING DOCUMENTS

Final Report.

TITLE: The effect of molybdenum and niobium on the hot working of line pipe steels (Phase 1)	FUNDING CANMET: \$ 24 992.00	PROGRAM: Energy ACTIVITY: Technology Devel.
CONTRACTOR: McGill University	CONTRACTOR:	
SCIENTIFIC AUTHORITY: G.E. Ruddle	DSS:	SUB-ACTIVITY: Oil and gas
TEL: 593-7136	OTHER:	SUB-SUB-ACTIVITY: Oil and gas pipelines
BEGIN/END: Apr. 1/78 - Mar. 31/79		
REQUISITION NO.: 23440-7-9107	TOTAL: \$24 992.00	PROJECT:

OBJECTIVES

To determine the effect of the microalloying elements Mo, Nb and V, on the precipitation and recrystallization rates in controlled rolling, with a view to enabling HSLA alloy design and roll pass scheduling to be carried out more rationally, and with less trial and error.

Phase I: The first phase of the investigation was to be performed at moderate strain rates on the McGill, Instron-based compression machine. Using the interrupted and other test methods developed in the laboratory, the effect of the microalloying elements in solution on the recrystallization kinetics was to be established. The precipitation kinetics of the various modified steels will also be determined.

PROCEDURE

Nine steel compositions were selected for investigation of the effects of Nb, V, Mo and Mn, singly and in various combinations, on the rate of recrystallization. The steels were machined into suitable compression specimens. Preferred grain orientation displayed in as-received material after austenization was eliminated by initially normalizing the material for 2 h at 1000°C in a vacuum furnace.

Prior to testing, specimens of four of the nine steels were austenitized as follows:

Nb steel - 1100°C, high Mn + Nb steel - 1100°C,
V steel - 1045°C, C steel - 1030°C. These temperatures were chosen to be above the carbide and nitride solubility temperatures, and to give ap-

proximately equal austenite grain sizes in all the materials. Compression tests of the four steels were performed at 925°C and at constant strain rates in the range of 10^{-5} to 1 sec^{-1} .

RESULTS

The influence of 0.035% Nb in solution, which leads to increased peak strain and therefore delayed initiation of dynamic recrystallization, is considerably greater than that of 0.115% V. The effect of 0.115% V in solution leads to a peak strain which is only slightly higher than observed in a plain carbon steel of similar composition. A comparison of two different plain carbon steels shows that an increase of 1.1% Mn and of 0.2% Si significantly increases the peak strain. The higher Mn level decreases the peak strain in the Nb steel. These observations confirm the original hypothesis that certain elements in solution can significantly retard the recrystallization kinetics, even in the absence of precipitation processes. Compression tests at 900 and 875°C are proposed to determine more completely the precipitation kinetics in the steels.

APPLICATION AND ONGOING WORK

The contract work has been continued into the second of three proposed phases.

SUPPORTING DOCUMENTS

J.J. Jonas - "Effect of molybdenum and niobium on the hot working of line pipe steels - Progress report; Mar. 31, 1979".

ENERGY PROGRAM

COAL

TITLE: Adaption and development of geo- physical techniques to Canadian coals	FUNDING CANMET: \$ 28 358.00	PROGRAM: Energy ACTIVITY: Research & Technology Development
CONTRACTOR: D. Masszi Consulting Services	CONTRACTOR:	
SCIENTIFIC AUTHORITY: W.A. Baxter	DSS:	SUB-ACTIVITY: Coal
TEL: (403) 284-0110	OTHER:	SUB-SUB-ACTIVITY: Mining
BEGIN/END: Oct. 10/78 - June 20/79		
REQUISITION NO.: 23440-8-9011	TOTAL: \$ 28 358.00	PROJECT:

OBJECTIVES

To prepare a state-of-the-art report with complete bibliography on geophysical techniques that have been or could be applied to coal mine exploration and development. This includes describing the physical principles of each technique; and listing the type and location of successful and unsuccessful field applications.

To itemize potential problems that could be encountered in Canadian field applications and directions that should be applied to future Canadian R & D.

PROCEDURE

A detailed literature survey of English and foreign language sources was done to determine what activities were presently being performed in centres outside Canada. This program was followed by visits to foreign research institutes and coal mining centres actively conducting applied geophysical trials to gain insight into problems encountered and the direction research is taking.

RESULTS

The report provides valuable background information that could be used by those presently contemplating using any of the wide variety of tech-

niques currently available. It points out numerous misconceptions and the necessity of further developments before some of the techniques could be modified for site-specific applications in Canada.

Work should be commenced to modify seismic and resistivity instruments and magnetometers so that they can be made intrinsically safe and licensed for use underground.

Theoretical studies should be carried out to determine if it is possible to develop or modify existing systems to achieve deeper penetration of a high frequency system.

APPLICATION AND ONGOING WORK

Project provided a good background on most of the major geophysical techniques that can be applied in Canada. It is hoped that scope of the work can be broadened and subsequent contracts to resolve critical problems as defined in the state-of-the-art review will lead to near-term field application in Canada.

SUPPORTING DOCUMENTS

Masszi, D. "To adopt and develop geophysical techniques applicable to Canadian coal"; CANMET Contract No. 78-9011 and microfiche.

TITLE: Optimization of coal recovery
from open pits

CONTRACTOR: University of Arizona

SCIENTIFIC AUTHORITY: D.F. Coates

TEL: 995-4179

BEGIN/END: June 9/77 - Mar. 31/78

REQUISITION NO.: 23440-7-9006

FUNDING

CANMET: \$ 53 918.60

CONTRACTOR:

DSS:

OTHER:

TOTAL: \$ 53 918.60

PROGRAM: Energy

ACTIVITY: Technology Devel.

SUB-ACTIVITY: Coal

SUB-SUB-ACTIVITY: Mining

PROJECT:

OBJECTIVES

To adapt the Pit slope manual for use by coal strip mines.

PROCEDURE

Advantage was taken of the opportunity to use the actual data of a coal mine in Wyoming whose personnel was interested in seeing results of an optimization design according to CANMET procedures. Canadian companies were approached to work on such a project, but for various reasons were unable to. Real-life geological, mining and cost data were used in the study to examine the effects on the net present value of the mine investment for two different highwall slope angles.

RESULTS

The results of the study demonstrated that the application to coal mines of the Pit slope manual is quite feasible in its present form but certain peculiarities of the deposits must be recognized. The case history illustrates the importance of the

staff of the actual mine formulating the cost of failure models. For this particular mine, it was shown that a highwall slope angle of 28° produced a higher net present value than a slope angle of 45° because of the greater frequency of instability of the latter and the resulting higher loss of coal.

APPLICATION AND ONGOING WORK

To provide a more complete optimization study, an addendum to the contract was issued for 78/79 to analyze the economics of an intermediate wall angle. When this additional work is completed, it will be combined with the previous work of 77/78, and a CANMET report on a case history of applying the Pit slope manual to coal will be issued.

SUPPORTING DOCUMENTS

Contractor's final report for 77/78 "Optimization of coal recovery from open pits" by Y. Kim and S. Wolff.

TITLE: Optimization of coal recovery from open pits (continuation)	FUNDING CANMET: \$ 25 022 (U.S.) \$ 28 000 (Can.)	PROGRAM: Energy ACTIVITY: Technology Devel.
CONTRACTOR: University of Arizona SCIENTIFIC AUTHORITY: D.F. Coates TEL: 995-4179 BEGIN/END: June 5/78 - Oct. 31/78 REQUISITION NO.: 23440-8-9010	CONTRACTOR: DSS: OTHER: TOTAL: \$ 25 022 (U.S.) \$ 28 000 (Can.)	SUB-ACTIVITY: Coal SUB-SUB-ACTIVITY: Mining PROJECT:

OBJECTIVES

To extend the field case analysis of a coal strip mine being subjected to the design procedure prescribed in the Pit slope manual so that it provides a complete model for Canadian operations.

PROCEDURE

A case study had been conducted in 1977/78. The results indicated that further work would be necessary to complete the example. Consequently, the contractor was reengaged to do the additional work.

RESULTS

With the analysis of the highwall slope angles of 28°, 35° and 45°, it was made clear that the optimum is close to 35°.

APPLICATION AND ONGOING WORK

A CANMET Report on a case history of applying the Pit slope manual to coal will be issued shortly. This report will be available to the industry and will be used in any industry workshops in coal mining areas that CANMET is organizing.

SUPPORTING DOCUMENTS

Contractor's final report for 78/79 "Optimization of coal recovery from open pits" by Kim, Wolff, Baafi and Cervantes.

TITLE: Control of methane roof layering in mine roadways	FUNDING CANMET: \$ 26 235	PROGRAM: Energy ACTIVITY: Technology Devel.
CONTRACTOR: Dames & Moore, Toronto	CONTRACTOR:	
SCIENTIFIC AUTHORITY: R.N. Chakravorty	DSS:	SUB-ACTIVITY: Coal
TEL: (403) 284-0110	OTHER:	SUB-SUB-ACTIVITY: Mining
BEGIN/END: Dec. 21/77 - Mar. 31/78		
REQUISITION NO.: 23440-7-9060	TOTAL: \$ 26 235	PROJECT:

OBJECTIVES

One of the major problems facing Canadian coal mines is controlling the explosive gas methane in mine air. Where the air velocity is low, methane emitted from the roof is likely to form roof layers; the methane layer so formed will mix slowly and inflammable concentrations may persist for hundreds of feet from the source. A part of these layers may be brought down by a fall of roof and mixing with air may produce an explosive mixture in the mine roadways. Control of methane roof layers is therefore essential for ensuring safe work environment in underground coal mines.

A study was initiated to review the problems associated with methane roof layers in coal mines and to document current practices to control methane layering in mine roadways. This study is a first attempt to match known technology with Canadian conditions and to identify the severity of the problem.

PROCEDURE

Surveying English and foreign language literature and documenting the relevant information on current technology dealing with methane roof layering problems.

Contracting, through visits and phone calls, the Canadian coal mine operators and evaluating the extent of the methane roof layering problem.

Reviewing methods used for controlling methane roof layering in foreign mines and evaluating their possible applications for Canadian conditions.

RESULTS

Problems of methane roof layering in mine roadways have been documented and the seriousness of the problem in Canadian coal mines evaluated.

In Western mines the problem at present seems to be less severe and improved ventilation practices should be able to deal with them effectively in most cases.

The problem appears to be more severe in Nova Scotia and it is felt that ventilation reorganization and a more effective methane drainage system would help considerably in controlling formation of methane roof layers and avoiding methane accumulations in mine roadways.

Recommendations are made for applied research programs on improved ventilation practices and methane drainage technology for some of the coal mines having a history of high methane emission rates.

APPLICATION AND ONGOING WORK

- (1) Applied research for possible reorganization of existing ventilation systems, and
- (2) improved methane drainage technology for controlling methane emission and roof layering in mine roadways.

SUPPORTING DOCUMENTS

Final report "Control of methane roof layering in mine roadways" prepared by Dames & Moore (Toronto) and H.G. Stephensen (Mining Consultants) Ltd., Canmore, Alberta.

TITLE: Engineering study of applicability of shortwall mining in the Lethbridge coal field		FUNDING CANMET: \$ 31 259.54	PROGRAM: Energy ACTIVITY: Technical Devel.
CONTRACTOR: Pacific Petroleum Ltd. Box 6666, Calgary, Alta.		CONTRACTOR: 31 259.54	
SCIENTIFIC AUTHORITY: F. Grant	DSS:	SUB-ACTIVITY: Coal	
TEL: (403) 284-0110 (Local 383)	OTHER:	SUB-SUB-ACTIVITY: Mining	
BEGIN/END: Oct./77 - June/78			
REQUISITION NO.: 23440-7-9008-2	TOTAL: \$ 62 519.08	PROJECT:	

OBJECTIVES

Pacific Petroleum mining department conducted feasibility and engineering studies to evaluate shortwall mining systems for mining coal efficiently at a proposed site in the Lethbridge coal field.

PROCEDURE

Extensive review of mining literature made.

Checked old mine plans, information and geologic data from former mines in area plus available literature.

Two test holes were drilled, cored, logged and tested plus check made on previous drill holes.

Inspection trip made after a 2-month postponement due to strike by miners.

Assessment made of equipment that might be suitable.

Prepared economic evaluation.

RESULTS

The results of this feasibility study are included in two volumes of final report. One volume consists of an interpretation by a consulting group, the other of Pacific Petroleum's evaluation.

Summary - The report does not favour shortwall mining methods as economic for producing coal from

the Lethbridge underground coal seam. The strata, roof and floor are weaker and more troublesome and the coal is probably harder than those of the mining areas examined. Core tests taken from the drill holes are inconclusive but do indicate weak strata.

Although Lethbridge conditions cannot be compared directly with those in shortwall mines, indications are that problems could be expected with this mining method.

The report recommends more drilling and bulk sampling to determine a more effective mining method. If this proves successful shortwall mining adaptations could then possibly be integrated with the method selected.

APPLICATION AND ONGOING WORK

Initial evaluation of the shortwall mining method was not favourable; additional research is indicated.

SUPPORTING DOCUMENTS

The final report was presented by A. Speed of Pacific Petroleum and K. Robinson representing Dames & Moore, Consultants, in Calgary on July 11, 1978, and at Ottawa on July 27, 1978.

TITLE: Preparation of a longwall under-ground mine feasibility study for the Alberta plains	FUNDING	PROGRAM: Energy
	CANMET: \$24 440.16	ACTIVITY: Technology Devel.
CONTRACTOR: Manalta Coal Ltd. Calgary, Alberta	CONTRACTOR: \$24 460.84	
SCIENTIFIC AUTHORITY: T.S. Cochrane	DSS:	SUB-ACTIVITY: Coal
TEL: (613) 996-4570 Ext. 150	OTHER:	SUB-SUB-ACTIVITY: Mining
BEGIN/END: Dec. 13/77 - May 31/78		
REQUISITION NO.: 23440-7-9008-1	TOTAL: \$48 901.00	PROJECT:

OBJECTIVES

Assess the potential for modern mining methods in the No. 1 Seam at the Atlas mine near Drumheller, Alberta.

lished for \$15.00, \$16.66 and \$18.33/t (\$13.50, \$15.00 and \$16.50/short ton) of coal.
4. The sub-contractor did excellent work - trial longwall or operational longwall will confirm the value of the study.

PROCEDURE

1. Review geological, tectonic and mining circumstances prevailing at the Atlas mine.
2. Choose the underground method of mining believed most suitable for the geological conditions in the Atlas mine.
3. Identify available reserves for the selected method of mining.
4. Detail development, production, capital expenditure and cash flow schedules for full-scale and experimental mining.

APPLICATION AND ONGOING WORK

This feasibility study is only Phase I of the total program which should eventually lead to a demonstration longwall under prairie conditions. Two debriefing sessions have been held to decide how to enter into Phase II. Company personnel are seeking markets for the coal. Trial mining cannot advance until an agreement can be reached on disposal of coal. Federal recommendation through CANMET is to proceed with "blocking out" contracts. Alberta Coal Mining Research Centre is also interested in the next phase of the study.

RESULTS

1. Full-scale longwall retreat mining recommended for Atlas mine conditions.
2. Production of 1.35×10^6 t/a (1.5 million short tons) a year from two longwalls plus related development considered possible.
3. Performance and economic parameters estab-

SUPPORTING DOCUMENTS

Stephenson, H.G. "Longwall mining feasibility study with particular reference to the Atlas mine. Vol. I and II. Confidential reports held in CANMET/MRL.

TITLE: The drying and briquetting of Estevan and Onakawana lignite	FUNDING CANMET: \$29 055.40	PROGRAM: Energy ACTIVITY: Sources, Supply, demand and substit.
CONTRACTOR: Manalta Coal Ltd.	CONTRACTOR:	
SCIENTIFIC AUTHORITY: P. Read	DSS:	SUB-ACTIVITY: Coal
TEL: 995-9351	OTHER:	SUB-SUB-ACTIVITY: Preparation
BEGIN/END: Jan./77 - Sept./77		
REQUISITION NO.: 23440-6-9086-5	TOTAL: \$29 055.40	PROJECT:

OBJECTIVES

To examine feasibility and benefits of drying or briquetting Estevan and Onakawana lignite for shipment to consumers remote from mines. The study was very practically oriented and concentrated on the behaviour of these lignites in the drying and briquetting processes currently applied to North Dakota and other lignites.

PROCEDURE

A pilot-scale roto-louvre dryer was temporarily installed at a mine near Estevan and used to dry both the lignites and Alberta sub-bituminous coal for comparison purposes. Onakawana lignite was dried from 45% moisture to about 35% but dust losses were estimated at 15 to 20% of the bone dry lignite charged. Estevan lignite was dried from 36% moisture to 26% although in one test the coal ignited. The Alberta sub-bituminous coal was dried from 25% moisture to 14% but also had fire problems in one test. Size degradation was apparent with Sheerness coal and occurred to the extent that fines were lost with the Onakawana coal but there was no substantial size degradation with the Estevan lignite.

It was found that binderless briquettes of good strength could be produced from finely crushed and dried Onakawana lignite. The Estevan lignite could not produce a strong briquette without a binder. In tests using a pitch binder, the Onakawana lignite required 20% by weight of pitch to make a strong briquette but the Estevan lignite needed only 10% and quite moderate pressures. Further tests on the dry Estevan lignite were done on a commercial scale briquetting double-roll

press rated at 2 t/h. Satisfactory briquettes were produced with 10 to 12% pitch added as a binder.

RESULTS

With the system as studied the energy required to remove moisture was rather high at approximately 7.5×10^9 J/t. At this heat rate there appeared to be no advantage to shipping dry coal compared with raw coal to the same destination.

It was found that binderless briquettes of good strength could be produced from finely crushed and dried Onakawana lignite. The Estevan lignite could not produce a strong briquette without a binder. In tests using a pitch binder, the Onakawana lignite required 20% by weight of pitch to make a strong briquette but the Estevan lignite tests were done on a commercial scale briquetting double-roll press rated at 2 t/h. Satisfactory briquettes were produced with 10 to 12% pitch added as a binder.

APPLICATION AND ONGOING WORK

Both southern Saskatchewan (Bienfait) and northern Ontario (Onakawana) lignites could be dried and briquetted. Due to the energy required to drive off the lignite's inherent moisture in the roto-louvre dryer, the cost of drying virtually matches the decreased transportation cost for the Bienfait lignite. With only a slight improvement in efficiency such a drying scheme could prove viable and briquetting appeared promising for Onakawana coal.

SUPPORTING DOCUMENTS

TITLE: Analysis of products from Canadian coal washeries	FUNDING CANMET: \$ 37 743.00	PROGRAM: Energy ACTIVITY: Technology Devel.
CONTRACTOR: Warnock Hersey Professional Services Ltd.	CONTRACTOR:	
SCIENTIFIC AUTHORITY: M.W. Mikhail TEL: (403) 467-8861	DSS: OTHER:	SUB-ACTIVITY: Coal SUB-SUB-ACTIVITY: Preparation
BEGIN/END: May 16/78		
REQUISITION NO.: 23440-7-9088	TOTAL: \$ 37 743.00	PROJECT:

OBJECTIVES

Analysis of product samples from Canadian washeries to determine separation characteristics and efficiencies of washing processes such as heavy medium, jigs, water-only cyclones and tables under industrial operating conditions.

PROCEDURE

Samples were collected by the Western Research Laboratory staff. Feed, clean coal and reject samples were provided to the contractor by EMR. Screen, float-sink, ash and sulphur analyses of samples from seven washeries were done by the contractor. Calculations to evaluate the performance of washing units based on the analyses mentioned above were carried out by WRL staff.

RESULTS

Phase I of the contract to establish performance of cleaning units was completed. On the basis of error curves data obtained from float-sink analysis, the following was determined.

1. Coarse cleaning units as applied to plus 9.5-mm (3/8-in.) coal performed well and up to expected standards.
2. Washing performance for units cleaning 9.5-mm x 500 µm (3/8-in. x 28 mesh) coal was reasonable for units considered but wide varia-

tion was found between washeries.

3. Froth flotation and water-only cyclones employed for cleaning minus 500-µm (28-mesh) coal performed below expectations and considerable losses of fine coal to refuse were found.

APPLICATION AND ONGOING WORK

1. Available information on seven washeries were communicated to washery supervisors in respect of their plants to make them aware of the performance of individual cleaning units and to make corrections if possible.
2. The available data can be used for the design of future plants that apply to particular coals e.g., friable coal.
3. The results indicate where research and development is required, i.e., 1.5 mm (minus 10 mesh) to reduce losses of saleable coal and improve recoveries.

Two more washeries will be sampled and evaluated during 1979-80 fiscal year.

SUPPORTING DOCUMENTS

A final report on the performance evaluation of Canadian washeries will be issued before the end of the fiscal year 1979-80.

TITLE: Thermal dewatering of Saskatchewan lignite	FUNDING	PROGRAM: Energy
CONTRACTOR: Saskatchewan Power Corp.	CANMET: \$ 9 886.15	ACTIVITY: Research & Technology
SCIENTIFIC AUTHORITY: J. Price	CONTRACTOR: \$ 9 886.15	
TEL: 996-4570	DSS:	SUB-ACTIVITY: Coal
BEGIN/END: June 19/78 - Mar. 31/79	OTHER:	SUB-SUB-ACTIVITY: Preparation
REQUISITION NO.: 23440-7-9128	TOTAL: \$19 772.30	PROJECT:

OBJECTIVES

The large (30 to 60%) bed moisture content of Saskatchewan lignites (reserves estimated at 6×10^9 t) lowers the fuel's calorific value and generally decreases boiler efficiency. Removal of water from Saskatchewan lignites is particularly desirable for economical long distance haulage to Manitoba and Ontario markets. The high temperature and pressure technique of thermal dewatering is a non-evaporative process that would remove water as a liquid from lignite and hence reduce energy costs compared with conventional evaporative methods.

PROCEDURE

Lignite samples from Estevan, Wood Mountain, Shaunavon, and LaRange, Saskatchewan; and Onakawana, Ontario were dried in a bench top 600 ml autoclave using the thermal dewatering technique. Two peat samples from LaRange, Saskatchewan were also tested. The samples were reacted under water in the autoclave between 150 and 300°C at the saturation pressure of water for residence times of 0 to 30 minutes. Moisture, proximate, C, H, N, S, and calorific analyses were made on the products. The effluent waters were analyzed for sodium. Materials and heat balances were made on selected samples.

RESULTS

Thermal dewatering was applied successfully to Onakawana and all Saskatchewan lignites tested with the exception of lignite (and peat) from LaRange. Optimum dewatering occurred at 300°C with 5 min residence times. Moisture content of Onakawana lignite, for example, was reduced from 45% to 10% which increased the calorific value from 10.14 MJkg^{-1} to 23.03 MJkg^{-1} . Approximately 1% of the original lignite was converted to gases (mainly CO_2 with some CO and H_2S). Nearly all sodium in Onakawana and two thirds sodium in Estevan lignites was removed by effluent water.

APPLICATION AND ONGOING WORK

Additional laboratory experiments at high temperatures are planned to minimize reactor residence times and to optimize the drying process. Future phases involve additional laboratory experiments in conjunction with a conceptual design and economic study of a commercial plant.

SUPPORTING DOCUMENTS

Final Report: Thermal dewatering of lignite.

TITLE: Electrostatic beneficiation of Hat Creek coal	FUNDING CANMET:	PROGRAM: Energy
CONTRACTOR: University of Western Ont.	CONTRACTOR:	ACTIVITY: Technology Devel.
SCIENTIFIC AUTHORITY: D.K. Faurschou	DSS: \$ 32 304	SUB-ACTIVITY: Coal
TEL: (613) 996-4570	OTHER:	SUB-SUB-ACTIVITY: Preparation
BEGIN/END: June 28/78 - May 31/79		
REQUISITION NO.: 23440-8-9022	TOTAL: \$ 32 304	PROJECT:

OBJECTIVES

The general objective was to investigate operational parameters and develop design criteria for the conceptual design of a modular full-scale electrostatic coal cleaning plant which could be demonstrated on a modular basis for the dry beneficiation of Hat Creek coal to below 30% ash (dry basis) but retaining 90% of the calorific value of the coal.

Specific objectives were to:

- (i) establish particle size ranges which could be beneficiated;
- (ii) establish permissible moisture levels;
- (iii) establish influence of relative humidity and use of stack gases for fluidization;
- (iv) characterize the Hat Creek coal and its mineral content for beneficiation purposes;
- (v) determine optimum electrostatic potentials and throughput conditions.

PROCEDURE

1. Constructed a fluidized bed, slot-type, free-fall pilot plant module having a design capacity of 50 g/s (450 lb/h);
2. characterized the coal, including its mineral content relative to the four Hat Creek zones;
3. operated the module to investigate the influence of independent variables related to the coal, to the module design and to optional process circuits;
4. developed relationships between performance and ash content, moisture and calorific value of feed and product.

RESULTS

For optimum beneficiation, the coal must have a particle size of <150 μ m, <3.5% free moisture, and where swelling clays are present the RH must be below 20%. Field intensities of about 2.0 kV/cm are required for good recovery and selectivity.

Recovery is dependent on initial ash content. The B.C. Hydro target was met by projection, starting with 37% ash. With 48 and 43.5% initial ash-levels, the calculated thermal recoveries were 71 and 78% respectively, for a 30% ash product. This was achieved with the most difficult to clean high clay coals.

Specifications are outlined for a 1000 t/d plant having overall dimensions of 3 m x 20 m x 1.4 m (height).

APPLICATION AND ONGOING WORK

Dry beneficiation is particularly relevant to Zones A, B & C of the Hat Creek deposit because of the shortage of water, lack of space for settling ponds, high ash content and high content of kaolin and swelling montmorillonite clays. Saskatchewan lignites may also be more amenable to dry than to wet beneficiation. Application could only be considered for on-site power generation and would entail offsetting costs for additional coal handling and storage facilities. Selection of the process may depend on environmental constraints.

SUPPORTING DOCUMENTS

UWO Report F010-B2-Electrostatic beneficiation of coal mined at Hat Creek, British Columbia, to make low ash concentrates; 21 July, 1979.

I.I. Inculet, R.M. Quigley, M.A. Bergougnou and J.D. Brown.

TITLE: Degradation of coke in the blast furnace	FUNDING CANMET: \$ 26 392.00	PROGRAM: Energy ACTIVITY: Research & Technology Development
CONTRACTOR: McMaster University	CONTRACTOR:	
SCIENTIFIC AUTHORITY: J.F. Gransden	DSS:	SUB-ACTIVITY: Coal
TEL: 996-4570 Ext 192	OTHER:	SUB-SUB-ACTIVITY: Carbonization
BEGIN/END: Mar. 23/78 - Mar. 31/79		
REQUISITION NO.: 23440-7-9103	TOTAL: \$ 26 392.00	PROJECT:

OBJECTIVES

Alkalies in the blast furnace cause coke degradation which means lower furnace productivity and higher fuel rates. The objective of this contract is to determine the mechanism by which alkalies decrease coke strength so that their effect can be minimized.

PROCEDURE

A number of cokes, carbon brick and electrode graphite were impregnated with potassium by exposing them to argon containing between 10^{-4} and 10^{-2} atmospheres of potassium vapour at temperatures between 800 and 1000°C for 1-1/2 h. The tensile strength of the specimens after cooling were measured and microscopy was used to determine structure changes. The potassium concentration gradient in the specimens were measured with an electron microprobe.

RESULTS

Potassium entered into carbon structures and ex-

panded them. More graphitized carbon structures absorbed less potassium. Carbon brick and a formed coke apparently cracked as they contained particles with different degrees of graphitization and expansion. More homogeneous carbon samples like blast furnace coke cracked when there was a potassium concentration gradient in the sample. Conditions that increased the gradient e.g., larger rates of potassium impregnation and lower temperatures increased the amount of cracking. Fine ash particles, and carbonaceous inerts such as fusinite did not appear to influence cracking caused by potassium.

APPLICATION AND ONGOING WORK

Work is to continue on the combined effect of alkali and CO_2 attack on coke under conditions found in a blast furnace.

SUPPORTING DOCUMENTS

Report: P.C.K. Chow, W-K Lu, Degradation of coke in the blast furnace due to alkali vapour.

TITLE: Scale-up design of the British Columbia wood-waste gasifier	FUNDING	PROGRAM: Energy
CONTRACTOR: H.A. Simons (International) Ltd.	CANMET: \$19 000.00	ACTIVITY: Technology Devel.
SCIENTIFIC AUTHORITY: M.M. Avedesian	CONTRACTOR:	
TEL: 996-4570	DSS:	SUB-ACTIVITY: Coal
BEGIN/END: Mar. 23/78 - Mar. 31/78	OTHER:	SUB-SUB-ACTIVITY:
REQUISITION NO.: 23440-7-9068	TOTAL: \$19 000.00	PROJECT:

OBJECTIVES

1. To determine the total capital requirements for an 8.8 MW (30 x 10⁶ Btu/h) output gasifier, scaled up from the existing B.C. Research gasifier. The cost estimate shall be based on a close-coupled hot, dirty gas application, located in Lower Mainland, British Columbia. The project scope shall commence at the inlet to the local hog fuel storage system and terminate at the outlet of the burner for low, calorific gas.
2. In preparing the estimate, preliminary mechanical drawings shall be made, together with process and control diagrams.
3. To report on gas cleaning equipment alternatives.

PROCEDURE

The engineering feasibility study performed by H.A. Simons (International) Ltd. was based on the B.C. experimental data shown in their report "Gasification of hog fuel" the basic design of the reactor, process and control diagrams, description and sizing of major equipment items were calculated using the best results from the B.C. report. Total capital requirements, gross operating cost and net annual savings were calculated for two options. The first option was a 30-unit storage bin with automatic discharge system and conveyors supplying the reactor hog fuel feed bins. The alternative scheme was a 200-unit hog pile with a drag conveyor supplying the two distributing conveyors which would feed the bins. The first scheme has sufficient storage for about 12 h whereas the alternative system will give sufficient storage for over a week-end.

RESULTS

Total capital requirements, operating costs and return on investment for the main scheme were \$1,144,384., \$1.25 for 10⁶ Btu's (about \$1.18 per 1000 MJ), and 1.3% respectively, and for the alternative scheme the costs were \$1,176,214., \$1.41 for 10⁶ Btu's (about \$1.34 per 1000 MJ) and 1.4% respectively.

The report identified potential trouble areas and additional tests that should be undertaken before construction of an 8.8 MW (30 x 10⁶ Btu) gasifier.

Because the gas has a variety of potential applications, the environmental considerations related to the following modes of operation were discussed.

- (1) Hot dirty gas (i.e., present case).
- (2) Hot clean gas (i.e., cyclone treatment for particulate removal).
- (3) Clean dry gas (gas cleaning by cyclones and condensers; potential uses include diesel or turbine fuel or synthetic gas production).

Total costs in order of magnitude for various gas cleaning systems were also given.

APPLICATION AND ONGOING WORK

None

SUPPORTING DOCUMENTS

Report

TITLE: Coal conversion	FUNDING	PROGRAM: Energy
	CANMET: \$72 768.00	ACTIVITY: Technology Devel.
CONTRACTOR: Shell Canada Resources	CONTRACTOR: \$72 768.00	
SCIENTIFIC AUTHORITY: P.J. Read	DSS:	SUB-ACTIVITY: Coal
TEL: 995-9351	OTHER:	SUB-SUB-ACTIVITY: Conversion
BEGIN/END: Jan./77 - Jan./78		
REQUISITION NO.: 23440-6-9086-4	TOTAL: \$145 536.00	PROJECT:

OBJECTIVES

To investigate: Modifications to gas boilers for low-heat-value gas; selection of the commercially available gasification system most suited to these requirements and matching the characteristics of available and sufficient coal; existing and potential market for intermediate heat value gas to define the distribution logistics and to determine the optimum site for the gasification plant, bearing in mind the need to make optimum use of waste heat, the supply of water, and the disposal and control of solid, liquid and gaseous effluents;

to develop a plan for mining, preparation and handling of the coal, including reclamation requirements and demands on utilities, labour and infrastructure;

to review the proposed gasification process for energy efficiency and modification as necessary to optimize the system for the given constraints and opportunities, including byproducts;

to develop a scheme for distribution and marketing the project gas with a view to achieving maximum flexibility in the future;

to prepare an economic assessment of the capital and operating costs of the complete proposed process including every aspect of mining, coal gasification, gas clean-up, gas distribution, and utilization with reference to utility and private-type financing as alternatives.

PROCEDURE

The conceptual plant size was established at approximately 160×10^6 MJ/d (i.e., 10^7 m³/d of gas at approximately 16 MJ/m³ which has an energy equivalent of approximately 5×10^6 m³ SNG per day) which would need two surface mines producing a total of some 18 000 t/d of sub-bituminous coal. Electric draglines would be used for stripping the overburden with shovels and front end loaders used for mining the coal. The coal would be transported a mean distance of 8 km to the plant in 100-t

trucks. Ash from the process and the boilers would be returned to the minesite for disposal. The process units chosen for the plant were a Lurgi fixed-bed gasification system, a Lurgi Rectisol gas purification system, a Stretford sulphur recovery system and a Lurgi Phenosolvan system for ammonia and phenol recovery. The gas would be delivered by pipeline to customer property lines at a pressure of approximately 2.2 MPa with continuity of supply assured by storing gas at 22 MPa in salt caverns.

RESULTS

The study concluded that total capital cost including the delivery system and start-up costs but not including interest during construction would be approximately \$670 million in constant 1977 dollars. Annual operation and maintenance charges for the plant at full production were estimated to be approximately \$52 million or 83¢/GJ with 100% equity, 47% tax rate 30% capital cost allowance and no royalties. The gas price required to produce a 15% discounted cash flow of return on investment was \$2.60/GJ. Tests were made of sensitivities to debt-equity ratio, royalties, capital costs, and operating costs. The return on investment was sensitive to debt equity ratios in joint venture cases and could remain over 15% with gas prices as low as \$2.00/GJ for high debt cases. Each dollar added to the cost of the coal at the mine or to the coal royalty would add approximately 11¢ or 15¢ per GJ respectively. For the base case of 100% equity it needed a decrease of 30% capital cost to reduce the required gas price to the target level of 1977 prices (1.90/GJ).

APPLICATION AND ONGOING WORK

None

SUPPORTING DOCUMENTS

Shell reports.

TITLE: Low severity coal liquefaction process	FUNDING	PROGRAM: Energy
	CANMET: \$59 002.50	ACTIVITY: Technology Devel.
CONTRACTOR: Nova Scotia Research Foundation	CONTRACTOR: \$59 002.50	
SCIENTIFIC AUTHORITY: J.F. Kelly	DSS:	SUB-ACTIVITY: Coal
TEL: 996-4570, Ext. 147	OTHER:	SUB-SUB-ACTIVITY: Conversion
BEGIN/END: Feb. 24/78 - March 31/78		
REQUISITION NO.: 23440-7-9033-7	TOTAL: \$118 005.00	PROJECT:

OBJECTIVES

To continue study of the extraction, coking and rehydrogenation of solvent phases of the Arthur D. Little coal liquefaction process as applied to Nova Scotia coal. The work will involve a systematic experimental bench-scale study of each phase and will include the building of a continuous flow system for rehydrogenation of solvent.

PROCEDURE

The ADL extractive coking coal liquefaction process was investigated using Nova Scotia bituminous coal from the Lingan mine. Bench scale stirred or rocker type, heated autoclaves were the principal means of investigating the three stages of the process under study - preparation of hydrogen donor solvent from raw anthracene oil, extraction of coal fines with donor solvent, and extraction/coking as a combined liquefaction-separation stage.

RESULTS

A six month experimental program on the liquefaction of Nova Scotia coal was completed. Conversions after 1-h extraction were typically about 60% of the m.a.f. coal using an anthracene oil as a donor solvent with a hydrogen content of 8.0 - 9.5%. After the coking stage, conversions were

37 - 43% of the m.a.f. coal, with the liquid yield being about 30%. Although ADL indicated that conversions of coal in the extraction stage were maximized at a solvent hydrogen content of 8.7%, the results of this study have not noted significant differences in the range of 7.9 - 10.1% H. Solvent to coal ratios of 2:1 to 4:1 did not cause significant differences in yield. Extraction time appears to affect conversion noticeably, increasing from 41% to 76% as extraction time increases from 0.5 h to 3.0 h.

APPLICATION AND ONGOING WORK

The next phase will concentrate on methods to increase liquid yield without varying from the low pressure approach. Solvent, which is currently produced batchwise, will be produced in a continuous flow apparatus. A continuous flow extraction apparatus is planned for future liquefaction work allowing higher hydrogen pressures if necessary.

SUPPORTING DOCUMENTS

Final report entitled "Low severity coal liquefaction process" by J.J. Starzomski and D.P. Sullivan, Nova Scotia Research Foundation Corporation, Project 3083, DSS File No. 18SQ.23440-6-9086, June 1978.

TITLE: Utilization of CO flue gases	FUNDING	PROGRAM: Energy
	CANMET: \$31 443.28	ACTIVITY: Technology Devl.
CONTRACTOR: Union Carbide Canada Ltd.	CONTRACTOR: \$31 443.28	
SCIENTIFIC AUTHORITY: J.F. Gransden	DSS:	SUB-ACTIVITY: Coal
TEL: 996-4570	OTHER:	SUB-SUB-ACTIVITY: Conversion
BEGIN/END: March 77/March 78		
REQUISITION NO.: 23440-7-9033-9	TOTAL: \$62 886.56	PROJECT:

OBJECTIVES

Obtain information on the quantity and quality of CO-containing off-gases from electric furnaces producing ferro alloys and develop methods of utilization the gas in-plant for slag remelting and as a substitute for liquid fuels presently used for raw material drying and sintering.

37% Co, had a flow rate of 3.3 m³/s (7015 SCFM) (dry), a heating value of 4.9 MJ/m³ (131.6 Btu/scf), a flame temperature of 1432°C (2610°F) and a particulate concentration of 0.049 g/m³ (0.0193 grains/scf). Furnace No. 14 off-gas analysed 52.5% CO, had a flow rate of 1.20 m³/s (2568 scfm) and a heating value of 6.74 MJ/m³ (180.9 btu/scf).

PROCEDURE

Standard methods were used to determine off-gas composition (CO, CO₂, CH₄, H₂, O₂), flow-rate, flame temperature and particulate loading over a 63-d period for two electric furnaces; six alternative methods were considered for utilizing off-gas for slag remelting.

A cupola operation was selected to melt slag using furnace off-gas and costs were estimated at \$20.61/t (\$18.81/nt, short) slag melted.

APPLICATION AND ONGOING WORK

nil

RESULTS

Furnace No. 18 off-gas (63-d average) analyzed

SUPPORTING DOCUMENTS

nil

TITLE: Liquefaction of low rank coals - Phase I	FUNDING CANMET: \$65 090.92	PROGRAM: Energy ACTIVITY: Technology Devel.
CONTRACTOR: Beak Consultants Ltd. Toronto, Ontario	CONTRACTOR:	
SCIENTIFIC AUTHORITY: J.F. Kelly TEL: 996-4570 Ext. 147	DSS: OTHER:	SUB-ACTIVITY: Coal SUB-SUB-ACTIVITY: Conversion
BEGIN/END: Dec. 1977/April 1978		
REQUISITION NO.: 23440-7-9059	TOTAL: \$65 090.92	PROJECT:

OBJECTIVES

1. Thermodynamic analysis of the liquefaction of coals at different operating conditions to gain insight into the composition of the products of liquefaction.
2. Determination of product quantity and quality from the liquefaction of various coals through batch autoclave studies.
3. Determination of optimum reactor conditions for the production of bitumen from coal.
4. Formulation of specific recommendations for future work, especially relating to the development and construction of a laboratory-scale continuous-flow reactor.

PROCEDURE

A computational procedure was developed at Beak to calculate equilibrium product distributions of a chemical system. The procedure has been used successfully to predict the products of the pyrolysis of peat at various operating conditions by determining the product concentrations which minimized the Gibb's free energy function of the system.

Beak modified the existing computational method to include non-ideal liquid phases and to predict the concentrations of products derived from liquefaction of coals.

To meet objectives 2 to 4, liquefaction experiments were conducted using a 1-L stirred batch autoclave located at the University of Sherbrooke. Attached analytical equipment allowed continuous monitoring of the gaseous products. After each experiment, the benzene soluble bitumen fraction was recovered and the conversion calculated. The product was then separated into asphaltenes and oils by an extraction with n-pentane. Finally, all products were physically and chemically characterized. From experimental results, optimum temperature, pressure, and reaction time for bitumen and oil production were determined.

RESULTS

Batch autoclave hydrogenolysis of a Saskatchewan lignite (Estevan) was conducted with carbon monoxide and hydrogen mixtures. Conversion and oil yields were measured as a function of reaction temperature (653 K to 733 K) initial total cold pressure (7.1 MPa to 11.1 MPa), residence time at reaction temperature (10 min to 50 min) and initial carbon monoxide mole fraction (0.25 to 0.75). Anthracene oil was used as vehicle solvent, at the solvent/lignite mass ratio of 2.8/1.

The experimental results were fitted to a statistical model using a partially replicated 2^4 factorial design. The model was found to be well adjusted for oil yields using Fisher's significance tests.

The highest conversions and oil yields obtained experimentally were 85.3% and 63.4% respectively, on a maf basis. Optimum oil yields were obtained using a low temperature (653 K), high CO concentration (0.75 molar), high initial cold pressures (11.1 MPa) and long residence times (50 min).

The liquid oil products obtained had an H content ranging from 5.7 to 6.4 wt. % and O content decreased to 2.0 - 3.6 wt. %.

APPLICATION AND ONGOING WORK

The present work will be extended to a semi-continuous reaction system for the investigation of a Western Canadian sub-bituminous coal. The catalytic reduction of oxygen in the liquid product oil will be investigated. A comparison of results with those obtained by U.S.A. researchers will be made for similar lignitic coals.

SUPPORTING DOCUMENTS

Final report entitled "Liquefaction of low rank Coals - Phase I" by Beak Consultants Ltd., Mississauga, Ontario, May, 1978.

TITLE: Small gasifier application study	FUNDING	PROGRAM: Energy
	CANMET: \$30 917.81	ACTIVITY: Res. & Tech. Devel.
CONTRACTOR: Saskatchewan Power Corp	CONTRACTOR: \$30 917.81	
SCIENTIFIC AUTHORITY: L.P. Mysak	DSS:	SUB-ACTIVITY: Coal
TEL: (613) 996-4570	OTHER:	SUB-SUB-ACTIVITY: Conversion
BEGIN/END: June 27, 1978 - March 1, 1979		
REQUISITION NO.: 23440-7-9055-III	TOTAL: \$61 835.62	PROJECT:

OBJECTIVES

To conduct a comparative techno-economic study on small gasifiers for plants in the range of 2.11 to 31.65 TJ/d (2 to 30 GBtu/d) both with air and oxygen injection using Saskatchewan coals. This is a follow-up work of the Coronach coal gasification study to look at small gasifier plants in the Saskatchewan context.

PROCEDURE

Gasifiers evaluated were Wilputte, Wellman-Galusha, Riley Morgan and Woodall-Duckham. Feedstock was coal from Estevan, Coronach and Shaunavon coal fields in Saskatchewan. Various suitable sites in Saskatchewan were identified where dedicated small gasifiers could be installed. Minimum consumption of natural gas at selected sites were not to fall below 2.11 TJ/d (2 GBtu/d). Case studies and an environmental study were carried out for two recommended sites.

RESULTS

All four gasifiers were found suitable for the production of low or medium calorific fuel gas in the range of 2.11 to 31.65 TJ/d (2 to 30 GBtu/d) using Estevan or Coronach lignite as feedstock. Design of a system using Shaunavon coal will require additional consultation with developers of the gasifiers and probably a pilot plant run. All four gasifiers studied can operate with oxygen to produce a medium heating value gas but the additional cost of an oxygen plant does not appear to be justified. The lowest cost industrial fuel gas is hot raw gas obtained with air-blown Wellman-

Galusha gasifiers. The two selected sites were Interprovincial Steel and Pipe Corporation Limited and Inland Cement Industries Limited, both in Regina, Saskatchewan.

A four-gasifier plant producing hot raw gas is recommended at each location. Costs for such facilities including retrofitting of existing natural gas fired furnaces were estimated at $\$6.3 \times 10^6$ for cost of facilities and $\$1.98/\text{GJ}$ ($\$2.088/10^6$ Btu) for cost of service at the IPSCO plant. At Inland Cement Industries, cost of facilities was estimated at $\$6.5 \times 10^6$ and cost of service at $\$2.10/\text{GJ}$ ($\$2.219/10^6$ Btu). The gasification plants can be designed to meet current and projected environmental legislation in the Province of Saskatchewan.

APPLICATION AND ONGOING WORK

SPC recommends that additional studies be carried out to determine the effect of using hot raw gas for a cement kiln operation, in particular the effect of a drop in flame temperature, a shorter flame, contamination by ash and sulphur and the possibility of using ash as raw material.

Should Saskatchewan Power Corp. advance to another phase in the consideration of small gasification plants, an analysis in much greater detail should be undertaken together with the technology vendor, as well as extensive examination of the selected site conditions.

SUPPORTING DOCUMENTS

Final report on file.

TITLE: Characterization and reactivity of thin carbon films	FUNDING CANMET: \$26 317.04	PROGRAM: Energy ACTIVITY: Res. & Tech. Devel.
CONTRACTOR: University of Ottawa	CONTRACTOR:	
SCIENTIFIC AUTHORITY: J.F. Kriz	DSS:	SUB-ACTIVITY: Coal
TEL: (613) 996-4570 Ext. 159	OTHER:	SUB-SUB-ACTIVITY: Conversion
BEGIN/END: Mar. 14/78-Mar. 31/79		
REQUISITION NO.: 23440-7-9073-3	TOTAL: \$26 317.04	PROJECT:

OBJECTIVES

To obtain fundamental information on reactions occurring during coal gasification through a study of the reactions of carbon films.

- to establish use of a new technique involved in the study
- to characterize the properties of thin carbon films in terms of hydrogen content and active surface area
- to correlate these properties with kinetic characteristics of reactions with oxygen and hydrogen.

PROCEDURE

The method involved the in situ measurement of the optical density of the carbon film inside the reaction vessel. The carbon film was prepared by pyrolysis of methane. The reaction vessel was a quartz cylinder, 2.2 cm id and 5 cm long, placed at the centre of a tubular furnace 50 cm long. The optical absorbance of the film was measured with the beam of a 2 mW-He-Ne laser (632.8 nm). The beam passed axially through the vessel, was filtered at the exit and measured using a photodiode. Gaseous products of the reactions investigated were analyzed by gas chromatography.

RESULTS

Detailed discussion of the results is available in the final report. All the work specified in

the work statement was performed. The objectives were met to the extent permitted by time limitations. The method was found suitable for characterization of carbon films. Results of part of the study dealing with reaction of the carbon film with oxygen have led to a concept of an active surface area being represented by carbon atoms in a strongly-bound complex with oxygen. A correlation was found between the active surface area and rate of removal of the carbon film by oxidation.

The mechanism involving participation of the complex has been suggested. Results of the study of the reaction with hydrogen were interpreted on the basis of product analysis. The importance of a surface reaction involving adsorbed hydrogen has been suggested.

APPLICATION AND ONGOING WORK

It is inherent in the technique that only relatively pure compounds in a suitable physical state can be successfully studied by this method. Application to more complex systems like coal would apparently not result in significant contributions and is therefore not recommended.

SUPPORTING DOCUMENTS

40-page final report "Kinetic study relating to gasification of coal characterization and reactivity of thin carbon films".

TITLE: Study of the reactivity of Sask. lignites as it pertains to their usefulness for gasification	FUNDING CANMET: \$58 186.84	PROGRAM: Energy ACTIVITY: Technology Devel.
CONTRACTOR: Saskatchewan Power Corp.	CONTRACTOR:	
SCIENTIFIC AUTHORITY: L.P. Mysak TEL: (613) 996-4570 Ext. 132	DSS: OTHER:	SUB-ACTIVITY: Coal SUB-SUB-ACTIVITY: Conversion
BEGIN/END: May 11/78 - Mar. 15/79		
REQUISITION NO.: 23440-7-9073-9	TOTAL: \$58 186.84	PROJECT:

OBJECTIVES

- (a) To evaluate the reactivity of lignite coals in Saskatchewan as to usefulness in gasification primarily for the production of fuel gases, methane and hydrogen.
- (b) To investigate the feasibility of using petrological techniques to assess the suitability of lignites for coal gasification.

dealing with experimental results and modifications to apparatus. Final conclusion is there appears to be no problem in gasifying lignite coal with air or air/steam mixtures.

- (b) Petrological study of lignite coals and some chars seems to indicate that the potential of lignite coal lies in the assessment of the ratio (structured luminate + liptinite): (unstructured + inert macerals).

PROCEDURE

- (a) Coal samples were fed into an externally heated reactor; reaction gases were fed from bottom and product gases exiting at top were collected for analysis.
- (b) Conducted literature search and study regarding lignite petrographical classification and consulted with prominent workers in lignite petrology and assessment. Prepared and examined samples of lignite with known gasification characteristics and samples of residue from the same gasification tests.

APPLICATION AND ONGOING WORK

- (a) Develop expertise in the area of coal conversion but also aid in the design and installation of future full-scale gasifiers. Continuation of study on air-steam mixture extended to oxygen-steam mixtures.
- (b) Petrological techniques provide a rapid and inexpensive optical method of analyzing lignites best suited for gasification.

RESULTS

- (a) Thirty-one experiments were conducted; number of recommendations and conclusions evolved

SUPPORTING DOCUMENTS

1. Copy of report
2. Microfiches

TITLE: Study of the optimization of
processes for generation and
combustion of coal gas

CONTRACTOR: Carleton University

SCIENTIFIC AUTHORITY: L.P. Mysak

TEL: (613) 996-4570 Ext. 132

BEGIN/END: April 1, 1978 - March 31, 1979

REQUISITION NO.: 23440-7-9073-IV

FUNDING

CANMET: \$37 148.00

CONTRACTOR:

DSS:

OTHER:

TOTAL: \$37 148.00

PROGRAM: Energy

ACTIVITY: Res. & Tech. Devel.

SUB-ACTIVITY: Coal

SUB-SUB-ACTIVITY: Conversion

PROJECT:

OBJECTIVES

- To develop a bench-scale facility to gasify coal, clean the gases of ash, and burn the gaseous products in a gas turbine type combustor
- to operate the facility to optimize conditions using Canadian sub-bituminous and lignite coals.

PROCEDURE

The fluid-bed gasifier and the auxiliary equipment used in the gasification system was designed and fabricated. Basic reactor dimensions are 7 cm in diameter by 70 cm in length with a free board section of 14 cm in diameter by 28 cm.

A number of test runs was conducted to "de-bug" the system.

RESULTS

The first year was devoted mostly to the first objective, with a few runs conducted to get an indication of whether or not the system was functional.

At gasification conditions close to that of design conditions (0.25 kg/h coal; 0.113 std m³/h oxygen, 0.625 std m³/h steam and 800°C bed temperature) the sample of Sundance mine sub-bituminous coal was converted to synthetic gas (24% CO, 34.8% H₂, 37% CO₂, 3.2% CH₄) with a heating value of 8372 kJ (2000 kcal)/std m³.

Combustion of simulated coal gas mixture was carried out in a development type combustor.

A second generation combustor to extend this aspect of the study has been designed.

APPLICATION AND ONGOING WORK

This work is being continued for a further year.

SUPPORTING DOCUMENTS

1. Copy of final report.
2. Microfiches.

TITLE: Coal liquefaction by concurrent grinding and hydrogenation	FUNDING	PROGRAM: Energy
CONTRACTOR: British Columbia Research Council	CANMET: \$40 370.00	ACTIVITY: Research and Technol.
	CONTRACTOR: \$3 880.00	
SCIENTIFIC AUTHORITY: K. Belinko	DSS:	SUB-ACTIVITY: Coal
TEL: 996-4570	OTHER:	SUB-SUB-ACTIVITY: Conversion
BEGIN/END: Aug. 1978 to April 1979		
REQUISITION NO.: 23440-7-9043-VIII	TOTAL: \$44 250.00	PROJECT:

OBJECTIVES

The overall objective of the study was to assess feasibility of hydrogenating coal in a vibration mill during grinding. Within this general objective, investigations were carried out to:

- confirm the novelty of concurrent grinding/hydrogenation
- set-up a suitable test mill
- investigate kinetics and liquid yields for selected coals over a range of operating conditions
- assess potential economic benefits of the process compared with current technology.

PROCEDURE

Three Canadian coals of different rank - a prairie sub-bituminous coal, an eastern high volatile bituminous coal, and a Rocky Mountain medium volatile bituminous coal - were selected for this study. A 70-mL reactor was charged with 7.5 g coal, 15 ml solvent (tetralin or creosote oil) and 100 g of stainless steel grinding balls.

The reactor was then secured to the vibrating mill and pressurized with hydrogen. The vibrating mill was started at the same time as the heating cycle. After completion of the desired time period at

temperature the reactor was allowed to cool and the reaction products recovered and extracted with appropriate solvents.

RESULTS

Liquefaction of coal under concurrent grinding/hydrogenation conditions was found to be technically feasible. Substantially lower reaction temperatures were required to hydrogenate the coal than in conventional processes. The relative reactivity of the three coals was as follows: Forestburg (sub-bituminous) >> Devco (hv bituminous) > Fording (mv bituminous).

APPLICATION AND ONGOING WORK

The possibility of patenting this process is presently being explored.

SUPPORTING DOCUMENTS

A report describing the results of tests carried out by BC Research to confirm the technical feasibility of coal liquefaction by concurrent grinding and hydrogenation will be released by the Scientific Authority once the question of patentability has been resolved.

TITLE: Design of a heating system using a fluid bed combustion unit	FUNDING CANMET: \$137 141.35	PROGRAM: Energy ACTIVITY: Technology Devel.
CONTRACTOR: Foster Wheeler Ltd.	CONTRACTOR:	
SCIENTIFIC AUTHORITY: F.D. Friedrich	DSS:	SUB-ACTIVITY: Coal
TEL: 996-4570 Ext. 185	OTHER:	SUB-SUB-ACTIVITY: Combustion
BEGIN/END: 24 Feb./78 - 15 Nov./78		
REQUISITION NO.: 23440-7-9051-1	TOTAL: \$137 141.35	PROJECT:

OBJECTIVES

The present contract is part of the Summerside Project, which has the following major objectives:

1. Demonstrate fluidized-bed combustion (FBC) as a viable means of burning coal in a heating plant boiler.
2. Demonstrate FBC of high-sulphur coal in a limestone bed as an economical and practical alternative to flue gas scrubbing as a means of controlling SO₂ emissions.
3. Demonstrate the use of wood chips as a supplementary fuel to coal in an FBC boiler.
4. Transfer foreign FBC technology to at least two Canadian suppliers.

PROCEDURE

A six-phase program was developed as follows:

Phase 1: Conceptual design of a fluidized-bed boiler.

Phase 2: Conceptual design of a heating plant to accommodate two FBC boilers.

Phase 3: Detailed design and cost approval of a heating plant addition with one FBC boiler.

Phase 4: Construction of a heating plant addition with one FBC boiler.

Phase 5: Testing and demonstration of FBC boiler with a range of coals and other solid fuels.

Phase 6: Procurement of second FBC boiler.

All work is being carried out by contract and to meet Objective 4, Phases 1, 2 and 3 are being carried out by two contractors working in competition. The present contract is one of two let for

Phase 1 work. The contractor prepared a conceptual design based on technology of the USA parent company for an FBC boiler to produce 18 000 kg of steam/h. The design was prepared without benefit of pilot-scale testing using the design fuels and limestone, but a separate contract for such testing is being negotiated.

RESULTS

The conceptual boiler design meets with requirements laid down in the contract work statement as follows:

Steam capacity: 4 000 to 18 000 kg/h

Fuel: - coal with 5% sulphur, sized 50 mm (2 in.) x 0, no coal preparation required.

- co-firing of wood chips, up to 30% of total heat input over the load range.

SO₂ emissions: Not to exceed DFE guidelines 0.07 kg/kJ (1.64 lb/10 Btu input) when burning coal with 5% sulphur.

Boiler efficiency: to exceed 80% over the load range.

The conceptual boiler design and supporting material have been collated into a report.

APPLICATION AND ONGOING WORK

The present contract is one of two for Phase 1 of the Summerside Project (see objectives).

SUPPORTING DOCUMENTS

"Conceptual design of a fluidized bed steam generator" November 1978 by Foster Wheeler Limited.

TITLE: Central heating plant report -	FUNDING	PROGRAM: Energy
CFB Summerside P.E.I.	CANMET: \$9 850	ACTIVITY: Technology Devel.
CONTRACTOR: Intercontinental Engineering Ltd.	CONTRACTOR:	
SCIENTIFIC AUTHORITY: F.D. Friedrich	DSS:	SUB-ACTIVITY: Coal
TEL: 996-4570 Ext. 185	OTHER:	SUB-SUB-ACTIVITY: Combustion
BEGIN/END: Dec. 15/78 - Jan. 2/79		
REQUISITION NO.: 23440-8-9052	TOTAL: \$9 850	PROJECT:

OBJECTIVES

A substantial body of data on the existing heating plant at CFB Summerside is required to facilitate conceptual plant designs for a proposed addition housing a fluidized-bed boiler demonstration. Two separate contractors are working on the conceptual plant design. One of them at an early stage collected much of the required data during an extended site visit and compiled it into a report.

The objective of the present contract was to make this information available to the second contractor rather than paying to have the same work done twice.

PROCEDURE

A separate contract was raised to purchase copies of the site visit report from the first contractor.

Price was negotiated by DSS on the basis of time and expenses incurred in gathering the data and preparing the report.

RESULTS

Site data required for both conceptual designs was collected and paid for only once.

APPLICATION AND ONGOING WORK

The present contract was in support of the Summerside Project, which is presently in Phase 2 of six planned phases.

SUPPORTING DOCUMENTS

Report entitled "Central heating plant, report on visit to CFB Summerside, PEI" by R.C. Hutchison, April 1978.

TITLE: Design of a boiler utilizing a fluid-bed concept for the combustion of coal and municipal waste	FUNDING CANMET: \$190 854.26	PROGRAM: Energy ACTIVITY: Technology Devel.
CONTRACTOR: Integ Intercontinental Eng. Ltd.	CONTRACTOR:	
SCIENTIFIC AUTHORITY: F.D. Friedrich TEL: 996-4570 Ext. 185	DSS: OTHER:	SUB-ACTIVITY: Coal SUB-SUB-ACTIVITY: Combustion
BEGIN/END: Feb. 17/78 - Feb. 28/79		
REQUISITION NO.: 23440-7-9051-II	TOTAL: \$190 854.26	PROJECT:

OBJECTIVES

The present contract is part of the Summerside Project, which has the following major objectives:

1. Demonstrate fluidized-bed combustion (FBC) as a viable means of burning coal in a heating plant boiler.
2. Demonstrate FBC of high-sulphur coal in a limestone bed as an economical and practical alternative to flue gas scrubbing as a means of controlling SO₂ emissions.
3. Demonstrate the use of wood chips as a supplementary fuel to coal in an FBC boiler.
4. Transfer foreign FBC technology to at least two Canadian suppliers.

PROCEDURE

A six-phase program was developed as follows:

- Phase 1: Conceptual design of a FBC
Phase 2: Conceptual design of a heating plant addition to accommodate two FBC boilers.
Phase 3: Detailed design and cost proposal of a heating plant addition with one FBC boiler.
Phase 4: Construction of heating plant addition with one FBC boiler.
Phase 5: Testing and demonstration of FBC boiler with a range of coals and other solid fuels.
Phase 6: Procurement of second FBC boiler.

All phases are being carried out by contract, and to meet Objective 4, Phases 1, 2 and 3 are being carried out by two contractors working in competition. The present contract is one of the two let

for Phase 1 work. The contractor, using a firm of British consultants as sub-contractors prepared a conceptual design based on UK technology for an FBC boiler to produce 18 000 kg of steam/h. Pilot-scale tests were also carried out.

RESULTS

The conceptual boiler design meets with requirements laid down in the contract work statement as follows:

Steam Capacity: 4 000 to 18 000 kg/h

Fuel: - coal with 5% sulphur, sized 50 mm (2 in.) x 0, no coal preparation required.

- co-firing of wood chips, up to 30% of total heat input over the load range.

SO₂ emissions: Not to exceed DFE guidelines 0.74 kg/10 kJ (1.64 lb/10 Btu input) when burning coal with 5% sulphur.

Boiler efficiency: to exceed 80% over the load range.

The conceptual boiler design and supporting material have been collated into a report.

APPLICATION AND ONGOING WORK

The present contract is one of two for Phase 1 of the Summerside Project (see objectives).

SUPPORTING DOCUMENTS

"Design of a boiler utilizing fluid-bed concept for the combustion of coal and waste product" August 1978 by Intercontinental Engineering Limited and Coal Processing Consultants Ltd.

ENERGY PROGRAM

NUCLEAR ENERGY

TITLE: Study on the removal of radionuclides from process streams	FUNDING CANMET:	PROGRAM: Energy
CONTRACTOR: Ontario Research Foundation	CONTRACTOR: \$19 996.40	ACTIVITY: Technology Devel.
SCIENTIFIC AUTHORITY: G.M. Ritcey	DSS:	SUB-ACTIVITY: Nuclear Energy
TEL: (613) 995-4124	OTHER:	SUB-SUB-ACTIVITY: Radioactive minerals
BEGIN/END: Apr. 10, 1978 - Jan. 19, 1979	TOTAL: \$19 996.40	PROJECT:
REQUISITION NO.: 23440-7-9116		
CONTRACT NO. OSQ78-00001		

OBJECTIVES

During the processing of uranium ores, one of the major environmental problems is that of the radionuclides of ^{230}Th , ^{226}Ra and ^{210}Pb in the tailings. Whereas it is recognized that some technology exists for the treatment of effluents by precipitation for control of ^{226}Ra , that route is not always effective.

The major ongoing project on uranium at CANMET is in leaching and purification, and in the development of new technology, the radionuclides are of real concern. The present short-term objectives are: (1) to determine the best practical technology for the treatment of effluents resulting from conventional technology, and (2) to develop technology whereby the radionuclides are solubilized and subsequently isolated for safe disposal. A comprehensive literature survey was therefore required covering the various techniques for removal of radionuclides from sulphate, nitrate, chloride or carbonate liquors.

PROCEDURE

1. Critically assess the literature on isolation and disposal and the chemical-analytical methods for radionuclides from chloride, sulphate, nitrate and carbonate liquors produced in uranium processing.
2. Review basic chemistry of the radionuclides of ^{226}Ra , ^{230}Th and ^{210}Pb .
3. Prepare a summary of the capital and operating costs for radionuclide disposal or isolation by selected processes.

4. Determine best practical technology and the chances for technical success for implementation of the isolation or disposal route for minimizing radionuclide levels for existing and non-conventional processing of uranium bearing ores and concentrates.

5. Propose a research plan for bench-scale evaluation of alternative isolation or disposal methods.

RESULTS

Monthly progress reports were received and at the end of the contract, a comprehensive report on the survey was issued. The conclusions indicated that although precipitation with barium chloride is presently used, difficulties are often experienced in attaining objectives. New technology for treatment of effluents suggests the use of ion exchange or other sorption processes as the routes to producing environmentally acceptable effluents from uranium milling operations.

Additional external contracting should proceed to complement CANMET's activity.

APPLICATION AND ONGOING WORK

No contract work in 1979-1980, but there is in-house R & D as a result of the ORF contract work.

SUPPORTING DOCUMENTS

Monthly reports and final report entitled "Study of the removal of radionuclides from process streams". Feb. 1, 1979.

MINERALS PROGRAM

DEVELOPMENT AND MINING

TITLE: Study of mining methods and ground control below 1216 m (4000 ft) at Elliot Lake uranium mines	FUNDING CANMET: \$7 995.74	PROGRAM: Minerals ACTIVITY: Technology Devel.
CONTRACTOR: Piteau & Associates Ltd.	CONTRACTOR:	
SCIENTIFIC AUTHORITY: D.G.F. Hedley	DSS:	SUB-ACTIVITY: Devel. and Mining
TEL: 705-848-2236	OTHER:	SUB-SUB-ACTIVITY:
BEGIN/END: March to June 1978		
REQUISITION NO.: 23440-7-9100	TOTAL: \$7 995.74	PROJECT:

OBJECTIVES

- a) To estimate possible extraction below 1216 m (4000 ft) using existing room-and-pillar mining methods.
- b) To compare conditions in Elliot Lake with gold mines in South Africa and determine whether South African mining methods can be adapted to Canadian conditions.
- c) To evaluate the feasibility of using either yielding pillars in a panel surrounded by barrier pillars or a caving mining system.

PROCEDURE

Visits were made to the three operating mines at Elliot Lake to evaluate ground conditions. Existing literature and the experience of S. Budavari from the University of Witwatersrand was the basis for comparing South African and Canadian mining practice.

RESULTS

Present layout of rooms and pillars will result in significantly lower extraction below 1216 m (4000 ft) and mining may not be economical below 1520 m (5000 ft).

Although rock conditions at Elliot lake and in South African gold mines are similar, the greater ore thickness at Elliot Lake prevents using the South African longwall caving system.

The most promising method at depth is to use small pillars in a panel surrounded by large stabilizing pillars. Extraction should be higher than in existing layouts.

APPLICATION AND ONGOING WORK

CANMET has been involved for 14 years on design of mining methods at Elliot Lake. Design guidelines for single and multi-seam mining down to 1212 m (4000 ft) have been written and are in use. This study points out where further research is required and also contributes to CANMET's cooperative study with Denison Mines Ltd. on pillar recovery.

SUPPORTING DOCUMENTS

A study of deep-level mining and ground control methods at the Elliot Lake uranium mines.

TITLE: Feasibility study of new mining concepts at depth in Canadian base metal mines	FUNDING CANMET: \$16 580	PROGRAM: Minerals ACTIVITY: Technology Devel.
CONTRACTOR: Mine-Met Consultants of Canada Ltd.	CONTRACTOR: est. \$30 000	
SCIENTIFIC AUTHORITY: D.G.F. Hedley TEL: (705) 848-2236	DSS: OTHER:	SUB-ACTIVITY: Devel. and Mining SUB-SUB-ACTIVITY:
BEGIN/END: Sept. 25/78 - Apr. 10/79		
REQUISITION NO.: 23440-8-9031	TOTAL: approx. \$46 580	PROJECT:

OBJECTIVES

1. To review the present state-of-the-art of mining technology with particular emphasis on mining base metals from deposits below 1000 m.
2. To develop recommendations on the economic and technical feasibility of introducing bulk mining methods which significantly improve productivity, lower mining costs, are inherently safer, and increase minable ore reserves.
3. To formulate proposals for field trials to prove the recommended methods.

1. High-speed drifting
2. Mining methods
3. Material handling systems
4. Preconcentration techniques with recommendations on:
 - a) tunnel boring machines
 - b) a reference manual on bulk mining methods at depth
 - c) testing of portable crushers and conveyor haulage systems
 - d) laboratory and field trials on preconcentration.

PROCEDURE

1. Review literature on mining statistics and recent technical innovations in mining.
2. Visit selected mining companies and equipment manufacturers.
3. Obtain in-house information on costs, productivity, mining methods, design planning, development equipment, material handling and preconcentration.

APPLICATION AND ONGOING WORK

A relatively large project has since been initiated on bulk mining methods at depth. A contract was given in 1979/80 to Falconbridge Nickel Mines Ltd. to design a bulk mining trial.

SUPPORTING DOCUMENTS

Final report.

RESULTS

Provided review of present mining technology on:

MINERALS PROGRAM

PROCESSING

TITLE: Study of creep and shrinkage measurements of lightweight concrete cylinders	FUNDING CANMET: \$4 550.00	PROGRAM: Minerals ACTIVITY: Technology Devel.
CONTRACTOR: University of Toronto, Toronto, Ontario	CONTRACTOR:	
SCIENTIFIC AUTHORITY: H.S. Wilson TEL: (613) 996-5617	DSS: OTHER:	SUB-ACTIVITY: Processing SUB-SUB-ACTIVITY:
BEGIN/END: July 2, 1976 - Sept. 1, 1977		
REQUISITION NO.: 23440-6-9038	TOTAL: \$4 550.00	PROJECT:

OBJECTIVES

This was part of a larger study of the properties of concretes incorporating various lightweight aggregates produced in Canada. CANMET does not have the facilities to do extensive creep and shrinkage measurements and this phase of the larger CANMET study was given as a contract.

PROCEDURE

Concrete cylinders were made in CANMET and shipped to the University of Toronto. They were individually prepared and mounted in creep frames. The cylinders were maintained under compression for one year and changes in length measured at specific intervals during that period. The results were shown graphically and were tabulated.

RESULTS

The creep and shrinkage results were as anticipated from similar studies in other countries. Lightweight concretes generally have larger creep and shrinkage values than do normal weight concretes.

APPLICATION AND ONGOING WORK

The results have been incorporated in a report covering the entire study, to be published by CANMET. The results of the study will be of value to those involved with the production and utilization of lightweight concrete.

SUPPORTING DOCUMENTS

"Report on a study of creep and shrinkage of lightweight concrete cylinders" R.H. Mills, University of Toronto, Toronto, Ontario, August 19, 1977.

TITLE: Study of natural pozzolans in British Columbia	FUNDING CANMET: \$23 060.00	PROGRAM: Minerals ACTIVITY: Technology Devel.
CONTRACTOR: R.M. Hardy and Associates Ltd. Calgary, Alberta	CONTRACTOR:	
SCIENTIFIC AUTHORITY: H.S. Wilson TEL: (613) 996-5617	DSS: OTHER:	SUB-ACTIVITY: Processing SUB-SUB-ACTIVITY:
BEGIN/END: Sept. 8, 1977 - Dec. 31, 1977		
REQUISITION NO.: 23440-7-9030	TOTAL: \$23 060.00	PROJECT:

OBJECTIVES

The energy required to produce cement is about 34.9 kJ/kg.^{°C} (7.5 million Btu's/ton). Certain glassy volcanic rocks, which, in the presence of moisture and lime, possess cementitious properties. These naturally-occurring pozzolans can be used as partial replacement of cement in the production of concrete.

This study was to determine if natural pozzolans occur within 250 km of Vancouver, B.C.

PROCEDURE

Potential deposits, identified from geological reports, were visited and sampled. The samples were evaluated according to ASTM specification C618, which details chemical and physical requirements. The rocks were also examined petrographically to determine their mineral constituents.

RESULTS

Ten samples from six locations were studied. Materials from three locations met all the requirements as to chemical and physical properties.

APPLICATION AND ONGOING WORK

The results were presented at the annual meeting of the CIM, in Vancouver in 1978.

The report of the contractor is being re-written for publication as a Mineral Sciences Laboratories report and submission to the CIM Bulletin for possible publication.

SUPPORTING DOCUMENTS

"Study of natural pozzolans in southern British Columbia" by R.M. Hardy and Associates Ltd., Calgary, Alta., Jan. 17, 1978.

TITLE: Simulation of a concentrator grinding and classification circuit	FUNDING CANMET: \$49 984.00	PROGRAM: Minerals
CONTRACTOR: Laval University, Ste-Foy, Que.	CONTRACTOR:	ACTIVITY: Technology Devel.
SCIENTIFIC AUTHORITY: I.B. Klymowsky	DSS:	SUB-ACTIVITY: Processing
TEL: 996-7953	OTHER:	SUB-SUB-ACTIVITY:
BEGIN/END: 1 Sept. 78 - 31 March 78		
REQUISITION NO.: 23440-7-9042	TOTAL: \$49 984.00	PROJECT:

OBJECTIVES

To develop a simulation model of a concentrator grinding and classification circuit for fine-grained sulphide ores. This model would permit a study of conditions which lead to the over-production of fines and held in defining a method of grinding the fine-grained sulphide ores of the New Brunswick area to minus 37 μ m (400 mesh) without producing excessive fines.

PROCEDURE

- (1) To develop a materials balance computer program, a residence time resolution program for continuous closed circuits, and parameter estimation programs that would permit analysis of Heath Steele sampling campaign results as well as results of laboratory batch and pilot-plant experiments on grinding and hydrocycloning.
- (2) To establish relationships between grinding and hydrocyclone model parameters and operating conditions.
- (3) To develop a simulation algorithm combining models of the grinding mills and hydrocyclones, and stimulate the present operating conditions of the Heath Steele grinding circuit.

RESULTS

Important transfers of technology were made to CANMET in the form of computer programs and methods of evaluating grinding and classification results. These programs included a materials balance, residence time determination, breakage and selection function determination, rod mill model, and a simulation algorithm. Relationships were established between selection function and hold-up weight in ball mills, between throughput and number of stages of breakage in rod mills, and between the water split coefficient and D50 size in industrial hydrocyclones and operating conditions. A simulation of the Heath Steele grinding circuit was carried out and presented at the CIM Conference in Montreal, Aug. 30/78.

The present hydrocyclone model, however, is valid only for limited extrapolation, and must be refined to extend its usefulness. In particular, more industrial experiments are required to determine the effects of hydrocyclone geometry and to overcome covariance of independent variables.

APPLICATION AND ONGOING WORK

The establishment of a fine grind with minimum extreme fines is necessary for high recovery of 90%+ that is the aim of the Comminution and Beneficiation Project. Efforts are made in industry to achieve such a grind but progress is slow because of many variables.

Because modelling and simulation reduce the number of variables and provide an understanding of their interrelationships, this approach has been adopted by CANMET. It is non-restrictive and can be applied to other ores. It is necessary to develop pertinent expertise particularly in view of industry demand for more automatic control and on-line optimization.

SUPPORTING DOCUMENTS

Reports submitted to CANMET.

Hodouin, D. "A Hierarchical optimization method for adjustment of industrial grinding data - Application to the Heath Steele Mines Circuit". draft version, July 1978.

Hodouin, D., Bérubé, M.A. and Evereli, M.D. "Algorithmes de calcul des fonctions B et S du modèle cinétique de la fragmentation", September 1977.

Bérubé, M.A. "La détermination expérimentale de la fonction de fragmentation en broyage discontinu", October 1977.

Bérubé, M.A., McMullen, J., Hodouin, D. and Everell, M.D. "Batch grinding experiments with the pyritic ore of Heath Steele Mines Ltd. (N.B.)", Research Report, No. 78-3, June 1978.

Fehr, M. and Everell, M.D. "Test procedure for hydrocyclone model studies at CANMET", October 1977.

Reports under preparation to be delivered

"Parameters for the simulation of Heath Steele grinding and classification circuit"; September 1978.

"Simulation of the Heath Steele grinding and classification circuit"; November 1978.

"Discontinuous pilot plant grinding test"; October 1978.

"Simultaneous determination of breakage and selection functions"; December, 1978.

TITLE: To process a CANMET produced zinc-lead-copper bulk concentrate through the Research and Productivity Council sulphation roast-leach process		FUNDING CANMET: \$14 985.48	PROGRAM: Minerals ACTIVITY: Technology Devel.
CONTRACTOR: New Brunswick Res. & Prod. Council		CONTRACTOR:	
SCIENTIFIC AUTHORITY: J.E. Dutrizac	DSS:	SUB-ACTIVITY: Processing	
TEL: 995-5823	OTHER:	SUB-SUB-ACTIVITY:	
BEGIN/END: Nov. 30, 1978			
REQUISITION NO.: 23440-8-9048	TOTAL: \$14 985.48	PROJECT:	

OBJECTIVES

Process a CANMET produced Zn-Pb-Cu bulk concentrate through the RPC sulphation roast-leach process to produce typical lead-silver-containing residues for evaluating methods of recovering lead and silver.

PROCEDURE

1. Sulphation roasted the bulk concentrate and leached the resultant calcine; the optimum conditions identified in previous demonstration trials were employed. Throughput rates were 90 kg/d based on 16 h/d operation.
2. Neutral leaching was carried out to iron oxidation to prepare recycle for the next neutral leach.
3. Neutral leach residue was hot acid leached to produce the lead-silver residue.
4. Three samples were provided: a sample representative of the transition from synthetic feed to

bulk concentrate; a bulk concentrate sample; and a sample representative of the transition from bulk concentrate to synthetic feed.

RESULTS

1. 120 kg of leach residue from the three processing stages (Procedure No. 4) were supplied to CANMET.
2. Analytical data for the residues were provided.
3. Final report outlining the test conditions was sent to CANMET.

APPLICATION AND ONGOING WORK

1. Ore Processing Laboratory is currently doing work to evaluate the upgrading of the residue by flotation.

SUPPORTING DOCUMENTS

Report by RPC.

TITLE: Study of ultra-high pressure technology	FUNDING	PROGRAM: Minerals
CONTRACTOR: Chadrien Co. Ltd.	CANMET:	ACTIVITY: Technology Devel.
SCIENTIFIC AUTHORITY: W.H. Erickson	CONTRACTOR:	
TEL: (613) 993-4929	DSS:	SUB-ACTIVITY: Processing
BEGIN/END: 12 Oct./78 - 26 Feb. 79	OTHER: DND \$25 000	SUB-SUB-ACTIVITY:
REQUISITION NO.: 23440-8-9058	TOTAL: \$25 000	PROJECT:

OBJECTIVES

The study should address the potential impact of ultra-high pressure technology field on the Department of National Defence (DND) in terms of existing and needed Canadian technology base and industrial capability.

The resulting report should contain specific recommendations for continuing R & D activities.

PROCEDURE

Initiated literature survey on behalf of DND in the use of ultra-high pressure technology and its application to defence-related materials.

The specific areas of study included:

- a) establishment of requirement for special equipment and engineering and cost considerations;
- b) kinetics of ultra-high pressures,
- c) applicability of failure criteria to materials under extreme conditions of loading (deterministic or probabilistic),
- d) materials likely to be incorporated in future defence systems, e.g., super-alloys for turbine blades, metal and ceramic compacts and their fabrication and repair processes, i.e., cubic boron nitride tooling.

RESULTS

This report provides access to the bank of knowledge of ultra-high pressure technology 5.0×10^5 to 2.0×10^7 kPa (50 to 200 kb), with special reference to methods suitable for synthesis of dia-

monds and cubic boron nitride.

A study of the design of actual ultra high pressure equipment, piston-cylinder and belt type, is made.

A review of suitable criteria on failure of tungsten carbide is given and the method of stress analysis is discussed.

The kinetics of ultra-high pressure processes with special reference to diamond synthesis is investigated and documented.

A short review of compacts and diamond compacts is provided.

The main objective of this report is to draw attention to the importance, from a national point of view, of development of ultra-high pressure technology in Canada.

APPLICATION AND ONGOING WORK

Department of Industry, Trade and Commerce (DITC) and DND are investigating opportunities for further work, leading to Canadian production of hard material to meet Canadian cutting and drilling needs.

SUPPORTING DOCUMENTS

"Study of ultra high pressure technology", Report on DSS Contract Serial No. OSQ78-00130 by Chadrien Company Ltd.

TITLE: Solubility of cuprous chloride in chloride media	FUNDING	PROGRAM: Minerals
	CANMET: \$16 505.25	ACTIVITY: Mineral Tech. Devel.
CONTRACTOR: Ontario Research Foundation	CONTRACTOR:	
SCIENTIFIC AUTHORITY: J.E. Dutrizac	DSS:	SUB-ACTIVITY: Processing
TEL: 995-4823	OTHER:	SUB-SUB-ACTIVITY:
BEGIN/END: 22 Feb. 79 - 31 May 79		
REQUISITION NO.: 23440-8-9119	TOTAL: \$16 505.25	PROJECT:

OBJECTIVES

1. Survey literature regarding CuCl solubility.
2. Measure CuCl solubility in various solutions of $\text{FeCl}_2\text{-HCl-NaCl-CuCl}_2$.
3. Solicit available data from Cominco, Duval, and Cyprus mines.
4. Present data in tabular and graphical forms.

PROCEDURE

Excess CuCl was added to the various solutions and stored in sealed jars. The jars were heated to various temperatures and the solutions sampled for CuCl. Data were obtained on heating and cooling. Solution densities were also measured.

RESULTS

1. In general, CuCl solubilities increased with increasing temperature and total chloride concentration.

2. The presence of CuCl_2 caused erratic results for which the reasons were not known.
3. Accurate solution density data over the temperature range of 25-95°C were produced.

APPLICATION AND ONGOING WORK

1. Results will be used in both the hydrometallurgical lead process and any new ferric ion leaching program.
2. Complementary CANMET studies on the solubilities of PbCl_2 , AgCl and CaSO_4 in similar solutions are underway.

SUPPORTING DOCUMENTS

Final report available.

MINERALS PROGRAM

UTILIZATION

TITLE: Effect of certain superplasticizers	FUNDING	PROGRAM: Minerals
on properties of concrete	CANMET: \$19 978.00	ACTIVITY: Technology Devel.
CONTRACTOR: University of Calgary	CONTRACTOR:	
SCIENTIFIC AUTHORITY: V.M. Malhotra	DSS:	SUB-ACTIVITY: Utilization
TEL: 996-5449	OTHER:	SUB-SUB-ACTIVITY:
BEGIN/END:		
REQUISITION NO.: 23440-6-9110	TOTAL: \$19 978.00	PROJECT:

OBJECTIVES

To generate data illustrating the effects of a number of commercially available superplasticizers on properties of concrete.

PROCEDURE

A series of concrete mixes were made with a water/cement ratio of 1:2. Mixes were designed to have a slump of 100 mm \pm 25 mm (4 \pm 1 in.) and an entrapped air content of 7 \pm 1%. Mixes were designed in accordance with ACI procedures. Setting times of fresh concretes were determined.

A large number of test specimens were cast to determine mechanical, elastic, freeze-thaw, creep and shrinkage determinations. Also, tests were carried out to determine air void spacing factors.

RESULTS

The addition of a superplasticizer to fresh concrete with preentrained air can immediately change the air content and subsequently promote decrease in air content with time. The initial change with Melment and Mulcoplast was an increase but there was little change with Mighty 150 and Lomar D. The subsequent time-dependent decrease is common to all, but appears less severe for Mighty 150. Despite their apparently inferior air void systems

- lower air content as indicated by the final pressure meter readings, larger average bubble size, and greater bubble spacing - the plasticized concretes except that with Mulcoplast, performed as well or better than equivalents without plasticizer, mix 50/B. Mixes using Melment and Mighty 150 appeared noticeably better in terms of all criteria; with Lomar D they seemed slightly better in durability factor and degree of scaling but the mix with Mulcoplast was noticeably inferior for all criteria.

Estimated values of total creep indicated that both Melment and Mighty 150 cause little change in properties from those of the unplasticized mix 50/B. On the other hand, Mulcoplast and Lomar D caused substantial increases - to the point where total creep was insignificantly different from the control mix 50/A. These conclusions were also borne out in examining one-year creep coefficients.

APPLICATION AND ONGOING WORK

Research is continuing at CANMET to explain some problems encountered.

SUPPORTING DOCUMENTS

A technical paper is under preparation.

TITLE: Development of a simplified accelerated curing test for concrete	FUNDING CANMET: \$10 059.08	PROGRAM: Minerals ACTIVITY: Technology Devel.
CONTRACTOR: B.H. Levelton & Associates, Vancouver	CONTRACTOR:	
SCIENTIFIC AUTHORITY: V.M. Malhotra TEL: 996-5449	DSS: \$10 300.00 OTHER:	SUB-ACTIVITY: Utilization SUB-SUB-ACTIVITY:
BEGIN/END: July 1977 - May 1978		
REQUISITION NO.: 23440-6-9114	TOTAL: \$20 359.08	PROJECT:

OBJECTIVES

- (a) To evaluate the degree to which the 7- and 28-day strengths of concrete test cylinders containing superplasticizers could be estimated by the modified boiling method.
- (b) To determine the effect of repeated doses of superplasticizers on the properties of concrete.

PROCEDURE

Objective (a) A series of 12 batches of concrete having a water to cement ratio of 1:2 and incorporating three commercially available superplasticizers were prepared; a number of test cylinders were cast for accelerated and standard moist curing

Objective (b) A series of laboratory mixes were prepared to simulate ready-mix concrete production. The variables included three types of superplasticizers and three water to cement ratios covering the normal range of commercial requirements. The properties of fresh and hardened concrete were determined.

RESULTS

Objective (a) The test results indicated that the relationship between accelerated strength tests, and standard 7- and 28-day strength was not influenced by adding superplasticizers.

Objective (b) Concrete lost flowability after 1 to 1.5 h. Each redose produced a reduction in entrained air of about 1.5%. Generally a specific dosage produced a higher slump in the second application than in the first or third. Difficulties were encountered in obtaining stable flowable concrete mixes at higher water to cement ratios - apparently due to lower cement content.

The first and second dosages resulted in 28-day strengths higher than the control cylinders. Lower strength increases, and in some cases marked reductions in the compressive strength occurred after the third dose.

APPLICATION AND ONGOING WORK

The data developed has direct application in the ready-mix concrete industry and is being applied by some producers in North America.

SUPPORTING DOCUMENTS

MRP/MSL 78-86 (OP) & (J)

Accelerated strength testing of superplasticized concrete and the effect of repeated doses of superplasticizers on properties of concrete by P.T. Seabrook and V.M. Malhotra.

TITLE: Use of superplasticizers as water reducers	FUNDING	PROGRAM: Minerals
	CANMET: \$19 000.00	ACTIVITY: Technology Devel.
CONTRACTOR: Ontario Hydro Research Lab.	CONTRACTOR: \$10 000.00	
SCIENTIFIC AUTHORITY: V.M. Malhotra	DSS:	SUB-ACTIVITY: Utilization
TEL: 996-5449	OTHER:	SUB-SUB-ACTIVITY:
BEGIN/END: Dec. 1977 - April 1978		
REQUISITION NO.: 23440-7-9011	TOTAL: \$29 000.00	PROJECT:

OBJECTIVES

To evaluate performance of superplasticizers as water reducing admixtures in concrete.

PROCEDURE

Various dosages of Melment L-10, Mighty 150 and Mulcoplast CF were added to air-entrained reference concretes and containing either Type 10, Type 20 or Type 50 cement to effect a 20% water reduction. Cement content, slump and air were maintained constant in all mixes. Specimens were tested for compressive strength, flexural strength, modulus of elasticity, shrinkage, creep and freeze-thaw performance.

RESULTS

Test results showed that in all cases the compressive strength, flexural strength and modulus of elasticity of the specimens cast from superplasticized concrete were in excess of those of refer-

ence specimens. With Type 10 cement, the concrete containing superplasticizers shrank more than the reference concrete, while with other cements shrinkage of the superplasticized and reference concretes were comparable. Type 10 Portland cement concrete containing Melment L-10 exhibited slightly higher creep than the reference concrete. The freeze-thaw durability of the superplasticized specimens containing either Type 10 or Type 20 cements appeared to be satisfactory; however, the combination of type 50 cement with superplasticizers showed very poor durability.

APPLICATION AND ONGOING WORK

A number of contractors in the precast industry are using data obtained from this work.

SUPPORTING DOCUMENTS

A technical paper is under preparation.

TITLE: Development of in situ strength tests for concrete	FUNDING	PROGRAM: Minerals
	CANMET:	ACTIVITY: Technology Devel.
CONTRACTOR: Laboratoire de Béton	CONTRACTOR:	
SCIENTIFIC AUTHORITY: V.M. Malhotra	DSS: \$28 681.40	SUB-ACTIVITY: Utilization
TEL: 996-5449	OTHER:	SUB-SUB-ACTIVITY:
BEGIN/END: Jan. 1978 - March 1978		
REQUISITION NO.: 23440-7-9043	TOTAL: \$28 681.40	PROJECT:

OBJECTIVES

Considerable work has been reported on the use of in-place pull-out tests for concrete; however, the major drawback of the existing pull-out tests is that they have to be planned during the design and erection of formwork. Another disadvantage is that the proposed location for the testing must be known to the contractor prior to placing of concrete. Investigations were thus undertaken to develop pull-out tests which could be carried out on the finished structures. Three possible approaches were considered:

- A - pulling out of tapered anchors placed in drilled holes
- B - pulling out of bolts set in hardened concrete by means of epoxy
- C - measuring pull-out force to cause shear failure of concrete using expansion bolts.

PROCEDURE

The three techniques were tried on 25 2.4 m x 1.2 m x 152 mm (96 X 48 X 6-in.) slabs. The concrete was obtained from a ready-mix producer covering a wide strength range from 17.1 - 41.3 MPa (2500 to 6000 psi) and a maximum aggregate size range from 9.5 - 38.1 mm (3/8 - 1 1/2 in.). A total of more than 1000 pull-out tests covering the three techniques were carried out.

RESULTS

Test results indicated:

1. Technique A gave relatively poor results in terms of reproducibility and the method had some inherent difficulties because of the torque-measuring system; it was thus discontinued.
2. The second approach involving grouting of bolts with epoxy appeared promising; however, problems arose associated with setting time of the epoxy and curing temperature control. It is believed that this approach is viable provided the right type of epoxy is obtained.
3. The third approach involving expansion bolts offered good possibilities and showed considerably less variation. Furthermore, simplicity of the test makes the method very attractive.

APPLICATION AND ONGOING WORK

Results of the project are being summarized in a technical paper for presentation at the Am Concr Inst Fall meeting at Houston, Texas, in October, 1978.

SUPPORTING DOCUMENTS

nil

TITLE: Survey and assessment of the technological capabilities of the Canadian foundry industry	FUNDING CANMET: \$32 200.00	PROGRAM: Minerals ACTIVITY: Technology Devel.
CONTRACTOR: Robert Shnay & Associates Ltd.	CONTRACTOR:	
SCIENTIFIC AUTHORITY: R.K. Buhr	DSS:	SUB-ACTIVITY: Utilization
TEL: (613) 993-7148	OTHER:	SUB-SUB-ACTIVITY:
BEGIN/END: July/1978 - February/1979		
REQUISITION NO.: 23440-7-9108	TOTAL: \$32 200.00	PROJECT:

OBJECTIVES

On behalf of Energy, Mines and Resources Canada, to conduct a study to define the technological capabilities of the Canadian foundry industry as a guide to formulating research programs and policies for EMR.

PROCEDURE

- Developed list of all operating Canadian foundries and investment casters by type, capacity, number of employees, product and principal type of castings. Contacted all foundries by questionnaire to determine:

1. levels of education,
2. on-the-job training,
3. level and type of process and quality control,
4. technical services offered,
5. product specifications and how verified.
6. customers buying specification,

- Phoned firms failing to reply and those where response incomplete or ambiguous,

- Visited major foundries to assess level of technology and company capabilities,

- Visited selected medium and small foundries,

- Visited casting buyers for comments on supplier's technology,

- Interviewed major buyers who import to determine reasons; where technological obtained details,

- Determined amount of imports due to lack of Canadian technology,

- Distinguished between lack of technology that would reduce cost and that which would widen product line,

- Carried out an in-depth study of three or four successful and unsuccessful foundries to determine requirements for upgrading technical capabilities,

- Developed a profile of the foundry industry with respect to technology as it affects production, management attitudes, processes employed,

environmental control and energy conservation practices,

- Recommended where R & D should be directed to increase viability.

RESULTS

The goals of the contract were met. A complete up-to-date listing of all operating foundries was supplied. Almost 47% of all Canadian foundries were included in the survey, considered an excellent response rate. A list of 12 research projects were identified as requiring research. Of these, 7 are in progress or have just recently been done. One of the more important findings was identifying that a significant obstacle to technology improvement was the lack of foundry-trained technicians and engineers: survey projected a need for 435 more over the next 5 years.

APPLICATION AND ONGOING WORK

Contacts were made with the federal government representatives in Manpower & Immigration and the Employment & Immigration Commission. Their mandate involves training of unskilled persons for periods of no more than a year, and so it is not applicable to the education requirements defined in the report. Letters were sent to appropriate personnel in all provincial governments in the hope that it would precipitate action on their part. A workshop dealing with energy conservation techniques employed by various foundries is being considered for next winter.

Internal reports of investigations into domestic sources of sand are being compiled and referenced.

SUPPORTING DOCUMENTS

Report. "Study and assessment of the technological capabilities of the Canadian foundry industry". All questionnaires received. Brochures received from certain foundries.

TITLE: Preparation of large concrete specimens for long-term durability studies in sea water environment off the coast of Maritime Provinces	FUNDING CANMET:	PROGRAM: Minerals ACTIVITY: Technology Devel.
CONTRACTOR: University of New Brunswick	CONTRACTOR:	
SCIENTIFIC AUTHORITY: G. Carette	DSS: \$17 318.84	SUB-ACTIVITY: Utilization
TEL: (613) 996-5449	OTHER:	SUB-SUB-ACTIVITY:
BEGIN/END: 20 June/78 - 30 Sept./78		
REQUISITION NO.: 23440-7-9131	TOTAL: \$17 318.84	PROJECT:

OBJECTIVES

- To study long-term durability of blast-furnace (BF) slag concretes under extreme exposure to sea water including freezing-and-thawing, salt water attack and wetting-and-drying.

PROCEDURE

- A large series of concrete prisms was made at U.N.B. The mix proportions covered a wide strength range, two types of cement and different percentages of BF slag.

After fabrication and curing, the prisms were transported by trucks to Treat Island, Maine for

long-term exposure to sea water attack.

The durability will be monitored using non-destructive testing methods.

RESULTS

- The work covers long-term studies and no results are yet available.

APPLICATION AND ONGOING WORK

nil

SUPPORTING DOCUMENTS

nil

MINERALS PROGRAM

ENVIRONMENTAL HEALTH AND SAFETY

TITLE: Continuous underground ventilation monitor system	FUNDING CANMET: \$44 607.96	PROGRAM: Minerals ACTIVITY: Technology Devel.
CONTRACTOR: Powers-Conspec	CONTRACTOR:	
SCIENTIFIC AUTHORITY: R.A. Washington	DSS:	SUB-ACTIVITY: Environmental Health and Safety
TEL: (705) 848-2236	OTHER:	SUB-SUB-ACTIVITY:
BEGIN/END: Sept. 16/1976 - March 31/1977		
REQUISITION NO.: 23440-6-9034	TOTAL: \$44 607.96	PROJECT:

OBJECTIVES

To develop a system for continuous monitoring of an underground ventilation system for air flow, barometric pressure, temperature, relative humidity, fire, dust, radon, methane, carbon monoxide, oxides of nitrogen, oxides of sulphur, and other contaminants or hazards; to trans for the ventilation engineer.

PROCEDURE

Sensors for all the desired parameters except respirable dust were selected, modified as necessary and field-tested. A data transmission system was developed and tested. A control mini-computer was installed, programmed, and tested.

RESULTS

The system has shown it is capable of measuring each required parameter at 2-min intervals and

transmitting the data to the computer on surface. The computer can provide an instantaneous readout on request; it can indicate an alarm condition if a sensor remains outside preset limits (high or low) for a minimum preset time; it computes a rolling average of the data from each sensor, and at the end of each shift it prints a report on the average conditions for each sensor for the full shift; and it can assemble all the shift-end reports and compute a month-end report of each average condition. It is also capable of operating a mini-board indicating the location and status for each sensor in the mine (green - O.K., red - out of limits).

APPLICATION AND ONGOING WORK

SUPPORTING DOCUMENTS

1. Copy of final report.

TITLE: Comparison of gravimetric dust samplers underground	FUNDING CANMET: \$100 000	PROGRAM: Minerals ACTIVITY: Technology Devel.
CONTRACTOR: Rio Algom Ltd, Elliot Lake in cooperation with ELL, MRL, CANMET	CONTRACTOR:	
SCIENTIFIC AUTHORITY: G. Knight	DSS:	SUB-ACTIVITY: Environmental Health and Safety
TEL: (705) 848-2236	OTHER:	SUB-SUB-ACTIVITY:
BEGIN/END: Sept. 76 to March 77		
REQUISITION NO.: 23440-6-9087	TOTAL: \$100 000	PROJECT:

OBJECTIVES

To compare two types of gravimetric samplers with the standard sampler fitted with a horizontal elutriator, and to determine relative performances in both underground and laboratory tests.

PROCEDURE

Twelve instruments were first compared in a standard laboratory dust cloud using accurately controlled airflows and their normal pumps. They were then used in the field with four sets of three side-by-side samplers of each type at 19 sites. The first was in the grinding area of a mill, 14 were in a mine with low diesel usage and 4 were in a mine with high diesel usage. The dust samplers collected dust on filters for periods of 4 to 6 hours and the dust samples were assessed by gravimetry for total respirable dust and by X-ray diffraction for respirable quartz dust.

RESULTS

The CAMPEDS was shown to be slightly more consis-

tent and reliable in mechanical performance than the M and H samplers. Both were much better than the standard instrument fitted with horizontal elutriator size selectors which, however, was mainly because of their poor mechanical condition. The CAMPEDS indicated 15% higher dust concentrations than the M and H in field tests but not in laboratory tests. It was not felt this difference was important at this time and that the choice between instruments should be made on the basis of acceptance by miners as well as of ease of use and maintenance by technical staff.

APPLICATION AND ONGOING WORK

The results of the project have been published as a CANMET MRL internal report and made available to the mining industry.

SUPPORTING DOCUMENTS

Knight, G. and Kowalchuk, R.K. "A Comparison of gravimetric dust samplers underground". MRL Report MRP/MRL 77-40 (IR).

TITLE: Evaluation of the CEA personal Alpha dosimeter	FUNDING CANMET: \$63 267.00	PROGRAM: Minerals ACTIVITY: Technology Devel.
CONTRACTOR: C.R. Phillips, Department of Chemical Engineering and Applied Chemistry, University of Toronto	CONTRACTOR:	
SCIENTIFIC AUTHORITY: H. Stocker Atomic Energy Control Bd.	DSS:	SUB-ACTIVITY: Environmental Health and Safety
TEL: 996-3783/995-9390	OTHER:	SUB-SUB-ACTIVITY:
BEGIN/END: January 21/1977 - March 31/1978		
REQUISITION NO.: 23440-6-9094	TOTAL: \$63 267.00	PROJECT:

OBJECTIVES

The main objective of the contract was to undertake an intensive series of laboratory and mine measurements to determine the basic operating characteristics of a personal integrating dosimeter for radon daughter exposure estimation for uranium miners. This device is manufactured by the Atomic Energy Commission of France (CEA). The device is of the track-etch type, in which alpha particles from the decay of radon daughters are recorded on a nitrocellulose film and after an etching procedure are read out by a method of direct hole counting or by light absorption techniques.

PROCEDURE

Laboratory tests were conducted to determine:

- (1) the flow calibration of each instrument,
- (2) the general response of the instrument to alpha radiation as defined by a standard method (Kusnetz),
- (3) the effect of filter change on flow characteristics,
- (4) the effect of humidity and water on the performance of the dosimeter,
- (5) the validity of etching and readout procedures as recommended by the instrument manufacturers.

A series of mine trials of various durations was conducted in two different Canadian mining environments to assess the performance of the instruments under actual mining conditions.

RESULTS

The results are contained in an interim and a final report.

Numerous defects in the basic design of the me-

chanical and electrical systems of the dosimeter and pump assembly were uncovered and rectified. These resulted in a more reliable and usable device. An error of theoretical consequence in the conversion of the dosimeter output to exposure estimation was also corrected.

Intensive laboratory tests were carried out on the dosimeters in a radon test chamber into which radon daughters could be introduced in a controlled manner. Aerosol generation and mixture with the radon daughters were controlled as well.

In the mines, the measurements of radon daughter exposures using the integrating dosimeters were compared with a standard method using time-weighted concentration measurements. Agreement was generally adequate within the 95% confidence level.

Drawbacks still exist with the dosimeter pump assembly design; improvements were recommended but have not been tested.

APPLICATION AND ONGOING WORK

The CEA personal radio daughter dosimeter performed adequately well in its first laboratory and mine trials. Its acceptability by the Atomic Energy Control Board must still be determined, however.

In an effort to improve understanding of the behaviour of this device in mine environments, the AECB has initiated a second contract in which the CEA dosimeter will be evaluated in a side-by-side comparison with another promising personal dosimeter based on the thermoluminescent dosimetry principle.

SUPPORTING DOCUMENTS

nil

TITLE: To investigate fire and explosion hazards of ammonium nitrate	FUNDING CANMET: \$27 080.00	PROGRAM: Minerals
CONTRACTOR: Queen's University, Kingston, Ontario	CONTRACTOR:	ACTIVITY: Admin. of Canada Explosives Act
SCIENTIFIC AUTHORITY: J.A. Darling	DSS:	SUB-ACTIVITY: Authorization and Testing
TEL: 996-4570, Ext. 190	OTHER:	SUB-SUB-ACTIVITY:
BEGIN/END:		
REQUISITION NO.: 23440-6-9122	TOTAL: \$27 080.00	PROJECT:

OBJECTIVES

To study factors which can lead to detonation of ammonium nitrate during storage and transportation with particular attention to behaviour in fires, and to determine conditions and procedures for its safe handling.

To review past and current literature, prepare a critique of proposed European tests, develop suitable tests and specifications and provide ongoing effective liaison of the committee with government and industrial agencies to ensure informed, objective attitudes to the problem of AN hazards and to the issue of classification.

PROCEDURE

During the year, the contractor critically reviewed the thermal decomposition mechanisms of ammonium nitrate and reviewed accidents involving ammonium nitrate. Field tests were done to determine the shock sensitivity of a number of ammonium nitrate samples. The EEC detonability test was also reviewed.

RESULTS

The results provided much of the initial information sought by the government relative to the classification of AN among dangerous goods for the purposes of transport.

APPLICATION AND ONGOING WORK

Results of the work to date have made government regulatory agencies and manufacturers more aware of AN hazards. On-going work will pinpoint additional hazards and determine conditions and procedures for its safe handling.

SUPPORTING DOCUMENTS

King, A. and Bauer, A. "A critical review of the thermal decomposition mechanisms of ammonium nitrate", "A review of accidents with ammonium nitrate", "A critical review of the EEC detonability test". Also King, A., Bauer, A., Preston, C.J. and Dunn, G. "Priming test data for assorted Canadian AN prills". All reports are confidential.

TITLE: To study the effect of surface treatment of tailings areas on quality and quantity of seepage	FUNDING CANMET: \$8 000	PROGRAM: Minerals ACTIVITY: Technology Devel.
CONTRACTOR: Rio Algom Limited	CONTRACTOR:	
SCIENTIFIC AUTHORITY: D.R. Murray	DSS:	SUB-ACTIVITY: Environment Health and Safety
TEL: 705-848-2236	OTHER:	SUB-SUB-ACTIVITY:
BEGIN/END: April 1/76 to March 31/77		
REQUISITION NO.: 23440-7-9003	TOTAL: \$8 000	PROJECT:

OBJECTIVES

Monitoring effluents, both surface runoff and seepage, from four test pits in uranium mill tailings variously treated by placing gravel, sawdust and vegetation.

To study effect of surface treatment on the quantity and quality of seepage and runoff.

treatments may begin to be noticed hereafter. The vegetated pit had 30% less seepage water and 30% less radium than the control pit. This was better than for either of the other treatments. All analysis of quality depends on rainfall so loading quantities varied. A report is available for more detail.

PROCEDURE

Maintained previously applied surface treatments and carried out regular chemical analysis of the effluent. The water flow was recorded to estimate quantity of water occurring as seepage.

APPLICATION AND ONGOING WORK

The value of vegetation for dust and erosion control and for aesthetics was demonstrated. Its value for seepage control and treatment requirements have not yet been determined and the contract is continuing to shed light on these aspects.

RESULTS

This was the 3rd year of a 5-year study during which surface treatments were applied in the 2nd year. Effluent from the tests pits started to be acidic as anticipated so that differences between

SUPPORTING DOCUMENTS

Progress report for 3rd year of cooperative program between CANMET and Rio Algom Ltd.

TITLE: Study of the use of tailings as backfill in Uranium Mines	FUNDING	PROGRAM: Minerals
CONTRACTOR: Watts, Griffis & McOuat Ltd. in association with Acres Consulting Services Ltd.	CANMET: \$20 922 1976 CANMET: 2 000 1977 CONTRACTOR:	ACTIVITY: Technology Devel.
SCIENTIFIC AUTHORITY: G. Allen	DSS:	SUB-ACTIVITY: Environmental Health and Safety
TEL: 704-848-2236	OTHER:	SUB-SUB-ACTIVITY:
BEGIN/END: Oct. 4, 1976 - Jan. 1978		
REQUISITION NO.: 23440-6-9032, 23440-7-9026	TOTAL: \$22 922	PROJECT:

OBJECTIVES

To prepare a review of mining and underground environmental conditions in Canada's four underground uranium mines with descriptions of mill tailings and of the portion to be used as backfill; to evaluate effect of radioactive elements contained in backfill material on the emission of radon/radon daughters into the mine air; to calculate volumes of air required for acceptable WL readings; to evaluate cemented backfill and synthetic resin to reduce radon emanation, and the effect of radioactive backfill on mine water; and to determine the benefits of using backfill.

PROCEDURE

The four u/g uranium mines were asked to submit details on their working environment including such aspects as mine air, water, mill tailings, and, tailing disposal facilities. Also requested were a 90-kg (200-lb) sample of mill tailings from each mine. Standard backfill tests were carried out, with 1:8 and 1:30 ratios of cement to backfill, to obtain a fill product with a 100-mm/h (4 in/h) percolation rate. The cemented portion of the backfill was subjected to compressive tests and all the samples were tested for radon emanation and chemical composition. The results of the emanation tests on the classified fill were used along with known emanation rate of wall rock to

assess the effect of the radioactive elements on the ventilating air. The effect of sealants to reduce the emanation rates was investigated from the literature, and the effect of backfilling on the quality of mine drainage water was explained.

RESULTS

The radon release rates for cemented tails were found to be higher than for the classified tails, contrary to theory. Only 13 - 33% of the radium in the tailings was present in the backfill portions. It was concluded that a backfill program would increase ventilation requirements while actively mining, however, the quantity of air required would be less on completion of mining. Sealants used should have "hole-free" conditions to be effective. Radon was not considered a problem to mine waste water but to the mine atmosphere.

APPLICATION AND ONGOING WORK

The results of this study have been summarized as a CANMET Report. Further work on the effects of moisture and the effects of cement on emanation rates is being carried out by CANMET.

SUPPORTING DOCUMENTS

Unpublished report "Study of the use of tailings as backfill in uranium mines"

TITLE: Diesel fuel emulsification for emission reduction from underground vehicles, Phase I	FUNDING CANMET:	PROGRAM: Minerals ACTIVITY: Technology Devel.
CONTRACTOR: Ontario Research Foundation	CONTRACTOR:	
SCIENTIFIC AUTHORITY: E.D. Dainty	DSS: \$94 754.51	SUB-ACTIVITY: Environment Health and Safety
TEL: 996-4570 Ext. 149	OTHER:	SUB-SUB-ACTIVITY:
BEGIN/END: Oct. 12/1977 to March 31/1978		
REQUISITION NO.: 23440-7-9052	TOTAL: \$94 754.51	PROJECT:

OBJECTIVES

To examine the feasibility of applying oil/water emulsified fuels or water induction in the intake manifold to a diesel engine derated for underground use, to reduce the level of toxic emissions, particularly NO_x and particulate matter released into the underground environment.

PROCEDURE

The Detroit Diesel (GM) 8v71N, 2-stroke direct injection diesel engine was coupled to an engine dynamometer. Numerous steady-state condition tests for several load/speed combinations were completed. The CO, NO, NO₂, O₂, CO₂, hydrocarbon, and particulate concentrations in the exhaust were measured for each engine operating condition for straight diesel fuel, for emulsified fuel, and for water induction in the intake manifold.

Particulate sampling was carried out at a point approximately 48 m (16 ft) from the manifold, using an EPA Method 5 sampling train employing isokinetic flow rates and maintaining the glass fibre filter assembly at 121°C (250°F).

RESULTS

Both water induction methods succeeded in reducing the NO_x by approximately 50%. Whereas water induction at ~0.9 kg/h (~2 lb/h) accomplished this

with modest increase in CO and hydrocarbons (THC), fuel/water emulsions (~45% water) resulted in 20 to 40-fold increases in CO and THC, respectively. Particulate measurements indicated low overall particulate generation (20 mg/m³) having a high hydrocarbon fraction (90%), in contrast to considerably higher values quoted in the literature for total particulate generation.

The next phase (II) of this investigation will confirm the suitability of the particulate measurement system and determine the effects on the levels of toxic constituents in the exhaust by treatment using an Englehard PTX monolithic catalytic purifier.

APPLICATION AND ONGOING WORK

Application: The results will provide necessary performance information on this toxicity reduction option thus contributing to the development of a relatively pollution-free vehicle for underground use.

Ongoing Work: See last paragraph of "Results".

SUPPORTING DOCUMENTS

Phase I - Final Report (Proposal P2512/G)
DSS Contract 1SQ77-00123 March 31, 1978.

TITLE: Continuous Monitoring of the underground mine environment	FUNDING CANMET: \$40 144	PROGRAM: Minerals ACTIVITY: Technology Devel.
CONTRACTOR: Powers-Conspec 44 Martin Ross Ave., Toronto, Ontario M3J 2K8	CONTRACTOR: \$10 000 approx	
SCIENTIFIC AUTHORITY: R. Tervo	DSS:	SUB-ACTIVITY: Environmental Health and Safety
TEL: 705-848-2236	OTHER:	SUB-SUB-ACTIVITY:
BEGIN/END: Sept. 77 to March 31, 78		
REQUISITION NO.: 23440-7-9056	TOTAL: \$50 144	PROJECT:

OBJECTIVES

To upgrade the Conspec underground mine environment monitoring system by changing from a mini-computer to a micro-computer based automation system for simple and more reliable operation.

To develop the computer system and software in the laboratory and to make it capable of operating with sensors located a kilometre (several thousand feet) away from the central monitoring station by improving the multiplexing system.

To develop interfaces to allow interrogation of each sensor independently in a system capable of monitoring and controlling many devices.

To demonstrate the system at Toronto and Elliot Lake.

PROCEDURE

Having established the design criteria, specifications were adopted for

- a) a remote data communications unit
- b) the number of remote points possible
- c) the types of possible sensors
- d) the function and operation of the monitoring system
- e) the input/output and processor configuration.

The multiplex system chosen was a unit called the Powers "Accensor" to act as an interface between sensors and the CPU.

The processor uses five micro-processors combined with 48 000 words of random access memory. The

total number of accensors is 128 per trunk for a maximum of 512. The system can handle 768 data points because some accensors can be multiple binary.

The development of programs to operate the system was a major task.

An accensor trunk 1.2 km (4000 ft) long was used in the final test.

RESULTS

The hardware and software were developed and tested satisfactorily at Toronto, Ottawa and Elliot Lake. The system can work with any sensor that provides an electrical analog signal (voltage or current) to represent the condition being tested. The development of suitable sensors for radon and radon daughters for continuous monitoring in uranium mines is necessary, plus a continuous dust sensor for other mines.

APPLICATION AND ONGOING WORK

The results are available in report form. Powers-Conspec have sold a system to USBM Pittsburgh, for installation in the research mine at Bruceton, Pa. Discussions are being held between Conspec and Devco for possible use in Cape Breton coal mines.

SUPPORTING DOCUMENTS

Powers-Conspec final report.

TITLE: Demonstration of vegetating 40 acres of uranium mill tailings at Elliot Lake, Ontario	FUNDING CANMET: \$71 594.30	PROGRAM: Minerals ACTIVITY: Technology Devel.
CONTRACTOR: The Company Farm Ltd.	CONTRACTOR: 3 000.00	
SCIENTIFIC AUTHORITY: D.R. Murray	DSS:	SUB-ACTIVITY: Environment, Health and Safety
TEL: 705-848-2236	OTHER:	SUB-SUB-ACTIVITY:
BEGIN/END: May 1978 to Nov. 1978		
REQUISITION NO.: 23440-7-9096	TOTAL: \$74 600.00	PROJECT:

OBJECTIVES

To demonstrate the application of establishing vegetation directly on uranium mill tailings as a first step in waste reclamation.

To verify on a commercial scale the practicality of the established procedure developed previously by CANMET staff.

To report on the suitability of the methodology and practical problems with its application on a reasonably large scale.

PROCEDURE

1. Removed debris from around the perimeter of the tailings area.
2. Landscaped the tailings area by removing tailings material and gravel and grading so that the surface slope was no greater than 18°
3. Spread limestone and fertilizer on the 16 ha (40 acres) in the following amounts:
 - limestone 5.6 ha (14 acres) slimes portion at 67.5 t/ha (30 tons/acre)
 - limestone 10.4 ha (26 acres) coarse portion at 22.5 t/ha (10 tons/acre)
 - fertilizer on complete 16 ha (40 acres) at 226 kg/ha (200 lb/acre); 10-20-20 or equivalent.
4. Incorporated limestone and fertilizer into top 75-150 mm (3-6 in) by rototiller and/or discs.
5. Fertilized, band seeded and compacted surface:
 - fertilized at 113 kg/ha (100 lb/acre); 0-46-0 or equivalent.
 - Seed Redtop, Creeping Red Fescue and Birdsfoot Trefoil in proportion 40/30/30 at 77.8 kg/ha (60 lb/acre).
6. Carried out maintenance fertilizing once in July and once in August.

RESULTS

A total of 14 of the 16 ha (35 of the 40 acres) were seeded, following the necessary liming, fertilization, cultivation and landscaping. Difficulties arose in drainage and access to approximately 4 ha (10 acres) and therefore some of the area was not accessible for treatment.

The project demonstrated that large scale vegetation establishment was possible with regular agricultural equipment on coarse tailings. Specialized equipment and careful timing of reclamation functions was critical for successful treatment of the fine tailings.

This was the first of a five year establishment scheme and as such was reasonably successful. Continued maintenance for a subsequent four years is required.

APPLICATION AND ONGOING WORK

The mining companies in the Elliot Lake area are now required to stabilize tailings areas. In co-operative research since 1971 many methods have been tested but the ones used for the final tailing treatment of seeding directly on the tailings. Practical application has thus been demonstrated. The vegetated area will provide a site for hydrologic studies and entrance to contaminants into the food chain.

SUPPORTING DOCUMENTS

Contractor report "Demonstration of vegetating 40 acres of uranium tailings at Elliot Lake, Ontario".

TITLE: Emission control of a Detroit Diesel 8V71N engine derated for underground use (Phase II)	FUNDING CANMET: \$36 626.10	PROGRAM: Minerals ACTIVITY: Technology Devel.
CONTRACTOR: Ontario Research Foundation	CONTRACTOR:	
SCIENTIFIC AUTHORITY: E.D. Dainty	DSS:	SUB-ACTIVITY: Environment Health and Safety
TEL: (613) 996-4570 ext. 149	OTHER:	SUB-SUB-ACTIVITY:
BEGIN/END: April 1/78 to March 31/79		
REQUISITION NO.: 23440-7-9097	TOTAL: \$36 626.10	PROJECT:

OBJECTIVES

- (1) To examine the feasibility of applying oil/water emulsified fuels, or water induction in the manifold of a GM8V71N 2-stroke direct injection diesel engine derated for underground use to reduce the level of toxic emissions (particularly NO_x) released into the underground environment
- (2) To assess the impact of an Englehard PTX-623 catalytic converter on the increased concentrations of total hydrocarbons and carbon monoxide generated by water addition to the combustion system.

PROCEDURE

The engine was dynamometer-tested at a number of loads and speeds employing the following combinations of equipment options:

- (1) water/oil emulsion system or intake manifold induction of water in aerosol form
- (2) fuel injectors, B5 and N90
- (3) fuel injection timing, standard and retarded 4 1/2°
- (4) catalytic converter treatment of "raw" engine exhaust

and for each configuration, gaseous and particulate emissions are sampled and reported by the contractor.

CANMET/MRL/CEAL applied the HEI* additive and synergistic criterion to interpolated emission results for a 213-m (700-ft) load-haul-dump cycle to estimate pollution impact on the underground environment by these configurations relative to the bare engine.

RESULTS

For reduction of NO by 50% it was necessary to add 45% or more water to the emulsion causing manifold increases in hydrocarbon and CO. This excessive water and the negative effect of the catalytic conversion of NO to NO₂ and of SO₂ to H₂SO₄ increased the exhaust toxicity more than the benefit

of the NO reduction, suggesting that this engine alone or in combination with a catalytic purifier appears unsuitable for the application of water/oil emulsions.

Other important options tested are compared below by the HEI* which is a direct measure of the ventilation requirement.

Option	Injector	Timing	Aerosol	PTX	HEI*
1	B5	standard	0	-	232
2	"	retarded 4 1/2°	0	-	177
3	"	standard	15.1 g/s**	-	199
4	"	"	0	installed	420
5	"	"	15.1 g/s**	installed	241
6	N90	"	0	-	229±

*HEI = Health Effects Index used as an overall toxicity index to assess emissions of engines and treatment devices.

**2 lb/min

Note that injection timing and constant aerosol water induction reduce emission toxicity by 24% and 14% and the addition of a catalytic purifier significantly increased toxicity relative to the bare engine.

APPLICATION AND ONGOING WORK

Work on the GM engine is completed. Development on a Deutz IDI engine employing water/oil emulsions will be continued because of its relatively low "raw" emissions toxicity and 50% NO reduction by only 15% water addition to the emulsion as determined in a parallel contract.

SUPPORTING DOCUMENTS

ORF Final Report of Phases I and II No. 2512/5

DSS Contract Number ISQ77-00183

TITLE: Decontamination of Elliot Lake uranium tailings	FUNDING CANMET: \$25 000	PROGRAM: Minerals ACTIVITY: Technology Devel
CONTRACTOR: Denison Mines Ltd., Elliot Lake, Ontario	CONTRACTOR:	
SCIENTIFIC AUTHORITY: D. Raicevic	DSS:	SUB-ACTIVITY: Environment Health and Safety
TEL: 996- 2778	OTHER:	SUB-SUB-ACTIVITY:
BEGIN/END: June 1978/Sept. 30, 1978		
REQUISITION NO.: 23440-7-9114	TOTAL: \$25 000	PROJECT:

OBJECTIVES

Laboratory- and continuous-scale test work at CANMET showed that over 95% of the pyrite, 60% of the uranium, 65% of radium-226 and 65% of the thorium were removed from the Denison Mines current uranium tailings thus practically eliminating pyrite, the major pollution hazard and considerably reducing the health hazards of radium, thorium and uranium in the new tailings. On the basis of these findings, CANMET felt that the stage has been reached to demonstrate this technology on a large pilot-plant scale at one of the operating mines at Elliot Lake. The Denison mill was chosen and a pilot plant flotation operation began in August 1978 on current Denison uranium tailings (leach residue). The prime objectives were:

1. to remove maximum amount of pyrite from the tailings in a pyrite concentrate and produce about 200 t of new tailings relatively free of pyrite for use in another research study related to seepage from tailings basins.
2. to remove maximum amount of uranium, radium and thorium from the original tailings and thus minimize these health hazards in the new tailings.

PROCEDURE

Flotation was the only method used for this operation, applying the same procedure developed at CANMET as recorded in Division report MRP/MSL 78-387 (IR).

Pyrite was floated separately using potassium amyl xanthate as collector and pine oil as frother, and a pyrite rougher concentrate was produced.

Uranium-radium-thorium concentrate was floated in two stages, rougher and scavenger, using a mixture of unsaturated fatty acids as collector.

Cleaning steps of the concentrates produced were not carried out as the objective of this operation was to produce the new-decontaminated tailings and discard the concentrates.

Two hundred tonnes of the decontaminated tailings produced were transported to the test pit of Rio Algom Ltd, for the seepage study from tailings basins.

RESULTS

(1) The results of the Denison pilot plant operation showed that over 98% of the pyrite was rejected from the current mill tailings producing new tailings practically free of pyrite.

(2) Over 65% of the radium-226, 55% of the uranium and 75% of the thorium were also rejected from the current mill tailings.

The pyrite and uranium-radium-thorium concentrates comprised 10% and 20% by weight of the original uranium tailings respectively. The new decontaminated tailings assayed:

- 0.03 - 0.13% sulphide S as pyrite
- 123 - 151 pCi/g radium-226
- 0.0035 - 0.0037% uranium
- 0.014 - 0.017% thorium

It was noted that the new (decontaminated) tailings produced by Denison contained a higher amount of radium-226 than that produced by CANMET test work where fresh water was used as repulping media whereas Denison used "repulping solution" containing between 586 and 1179 pCi/l radium-226. Using repulping solution instead of fresh water was felt to increase radium content in the decontaminated tailings.

APPLICATION AND ONGOING WORK

(1) The new (decontaminated) tailings are being used to study seepage problems from tailings basins.

(2) Possibility of recovering additional uranium from the concentrates produced is being considered.

(3) Total recovery of uranium could be increased by replacing most of the pillars with decontaminated tailings.

SUPPORTING DOCUMENTS

Report of Denison Mines Limited

"Pilot-scale study of pyrite and radioisotopes removal by flotation in the mill", by T.E. Pakkala, Mill Metallurgist of Denison Mines Limited; November 23, 1978.

TITLE: Retrofit potential of water/oil emulsification unit for reducing No_x emission from currently used underground diesel powered equipment

FUNDING: CANMET: PROGRAM: Minerals
ACTIVITY: Technology Devl

CONTRACTOR: Ontario Research Foundation CONTRACTOR:
SCIENTIFIC AUTHORITY: E.D. Dainty DSS: \$52 431.95 SUB-ACTIVITY: Environment
Health and Safety

TEL: (613) 996-4570 OTHER: SUB-SUB-ACTIVITY:
BEGIN/END: 10 May 78 - 31 Dec. 78
REQUISITION NO.: 23440-7-9120 TOTAL: \$52 341.95 PROJECT:

OBJECTIVES

- (1) To examine the feasibility of fueling a Deutz F6L714 diesel engine in widespread use underground with an oil/water emulsion prepared by an ORF hydroshear device, to significantly reduce the level of toxic emissions emitted into the underground environment
- (2) To assess effectiveness of the Englehard PTX catalytic purifier in treating the bare engine exhaust, and to assess impact of the added water on conversion of SO_2 to H_2SO_4 and of NO to NO_2 .

PROCEDURE

- (1) Determined the effects of injection retardation from 27° to 24° BTDC on the particulate and gaseous exhaust emissions for 10 load/speed engine operating conditions using neat fuel to establish a base line for comparing with fuel emulsification tests,
- (2) determined the effects of fuel water content on the gaseous emissions for the 10 load/speed conditions above and on the particulate emissions of both injection timings for 3 load/speed conditions, to determine the best combination of water addition and injection timing for toxicity reduction,
- (3) determined the effects of water addition on performance of the PTX purifier to assess toxicity impact, and
- (4) determined the negative effects of water addition on brake specific fuel consumption and power output.

SUPPORTING DOCUMENTS

ORF Final Contract Report No. 2722/02
DSS Contract No. ISQ78-00022, March 30, 1979

RESULTS

Configuration	Timing ($^\circ$ BTDC)	Water %	HEI*
engine	27	0	119.6
engine	27	27	77.7
engine	24	0	97.7
engine	24	15	72.5
engine + PTX	24	0	163.8
engine + PTX	24	15	116.2

*HEI = Health Effects Index used as an overall toxicity index to assess performance of engines and treatment devices.

Examination of the report and the above shows:

- (1) injection timing retardation from 27° to 24° BTDC reduces toxicity significantly,
- (2) 24° BTDC and 15% water is the best toxicity reduction strategy,
- (3) the purifier contributes a 68% negative impact on the environment relative to the bare engine which is reduced to 19% by 15% water addition,
- (4) 8% of the NO generated was converted to NO_2 for both the bare engine and for 15% water addition, and finally
- (5) the brake specific fuel consumption was unaffected by 15% water addition.

APPLICATION AND ONGOING WORK

These results are significant and indicate that such water/oil emulsions are effective in reducing toxicity of mining environments. Before installation and field testing of a prototype two practical matters remain to be determined:

- (1) the operating life of the engine oil-lubricated version of the fuel pump by means of bench tests, and
- (2) the feasibility of the final prototype fuel system design.

TITLE: Effect of surface treatment on tailings areas on quantity and quality of seepage	FUNDING CANMET: \$15 541.00	PROGRAM: Minerals ACTIVITY: Technology Devel
CONTRACTOR: Rio Algom Limited	CONTRACTOR: 15 541.00	
SCIENTIFIC AUTHORITY: D.R. Murray	DSS:	SUB-ACTIVITY: Environment Health, Safety
TEL: (705) 848-2236	OTHER:	SUB-SUB-ACTIVITY:
BEGIN/END: June 27/78 - March 15/79		
REQUISITION NO.: 23440-7-9124	TOTAL: \$31 082.00	PROJECT:

OBJECTIVES

To study the effect of surface treatment on the quality and quantity of effluent water by applying sawdust, gravel and vegetation on uranium mill tailings.

To construct and fill a test pit with pyrite-free tailings for similar studies.

PROCEDURE

1. Made daily records of effluent flow rates, precipitation, and mean temperature (maximum and minimum).
2. Took biweekly and monthly samples from the effluent flow for various chemical analyses according to a predetermined schedule.
3. Maintained test pits in a neat and orderly state.
4. Excavated a pit and placed a hypalon liner, tile drain and overflow drainage pipes with the necessary instrumentation in the sampling shed to record flow rates and to permit quality sampling.

RESULTS

A new pit was constructed and maintenance of the previous pits was completed. Sampling and daily flow records made as required.

This is year 4 of a 5-year data acquisition program. There are trends starting to develop. The untreated tailings pit turned acidic and started producing noxious effluent. The gravel, sawdust and vegetated pits have not yet shown any significant difference in quality studies.

The sawdust pit produced significantly more effluent quantity than the other pits subjected to treatment with no significant difference between vegetated and bare tailings as the lowest flows. The report prepared on the four years of data describes pit differences and recommends an extension of the monitoring program for at least 2 years beyond the end of the 5-year program.

APPLICATION AND ONGOING WORK

There is great interest in knowing the effect on effluent quality by adding a vegetative cover to uranium mill tailings. This is the only program of this scale in Canada and will be continued until reliable recommendations or conclusions can be made.

SUPPORTING DOCUMENTS

"Effect of surface treatment of tailings on quantity and quality of effluents, by D.R. Murray, D.N. Okuhara; March 1979; MRP/MRL 79-21 (TR).

TITLE: To investigate the hydrology underlying uranium mill tailings at Elliot Lake, Ontario	FUNDING CANMET: \$20 264.00	PROGRAM: Minerals ACTIVITY: Mineral Technology Development
CONTRACTOR: W.L. Wardrop & Associates Ltd.	CONTRACTOR:	
SCIENTIFIC AUTHORITY: V. Dekorompay	DSS:	SUB-ACTIVITY: Environment, Health, Safety
TEL: (705) 848-2236	OTHER:	SUB-SUB-ACTIVITY:
BEGIN/END: July 14/78 - Sept. 30/78		
REQUISITION NO.: 23440-7-9136	TOTAL: \$20 264.00	PROJECT:

OBJECTIVES

To define the hydrogeological conditions and to determine the hydraulic characteristics of the deposited mill tailings and the formations underlying the Nordic West Arm tailing pond.

PROCEDURE

Four stratigraphic test holes have been drilled to define the geological conditions beneath the tailings pond.

One pump well for the mill tailings and one for the glacial till formation were completed and pump tests conducted.

Analysis of the pump test results established the hydraulic characteristics of the formations.

A total of 32 washed and 14 split spoon samples were collected during drilling.

RESULTS

Based on the results of the stratigraphic test holes, a hydrogeological profile across West Arm

tailings pond was prepared. Hydraulic parameters such as transmissibility, permeability storage coefficient and flow gradient were established.

The samples obtained provided material for radiochemical investigation.

The wells are used as water sampling points to monitor water quality in the formations.

APPLICATION AND ONGOING WORK

The final report has been sent to Rio Algom Limited to provide information for the recent rehabilitation work in connection with the West Arm tailings pond.

The results were used for designing the research program of "Hydrogeological investigation of the West Arm of the Nordic tailings pond" - No. 23440 - 1979.

SUPPORTING DOCUMENTS

W.L. Wardrop and Associates Ltd.'s final report.

TITLE: Management of an information/ research program on occupational health and safety aspects of uranium production	FUNDING CANMET: \$95 599	PROGRAM: Minerals ACTIVITY: Technology Devel.
CONTRACTOR: Elliot Lake Centre SCIENTIFIC AUTHORITY: D.G.F. Hedley	CONTRACTOR: \$125 000 DSS:	SUB-ACTIVITY: Environmental Health and Safety
TEL: (705) 848-2236	OTHER: \$100 000	SUB-SUB-ACTIVITY:
BEGIN/END: Oct. 18/78 - March 15/79		
REQUISITION NO.: 23440-8-9007	TOTAL: \$320 599	PROJECT:

OBJECTIVES

1. To establish a sputum cytology service for uranium miners in Ontario.
2. To produce three audio-visual modules on aspects of uranium mining and its effect on the local population.

PROCEDURESputum Cytology

1. Distribution centre for sputum samples set up at Elliot Lake and Bancroft.
2. Sputum analysis done in Toronto.
3. Project coordination by Dr. Band, Cancer Institute, Montreal.
4. Statistical evaluation at University of Rochester.

Information Modules

1. Groups set up to write script, produce graphics and other visual material.
2. Script edited by professionals in respective fields.
3. Production of modules done on sub-contract.

RESULTS

419 miners at Elliot Lake and Bancroft participated in sputum cytology program. Information module on sputum cytology being used by mines in Canada and U.S.A to promote volunteer participation.

Information modules on radiation aspects are in a form for showing on Cable TV and in a style suitable for the local population.

APPLICATION AND ONGOING WORK

Sputum Cytology program going ahead, but totally funded by uranium mining companies.
Possibility of using information modules to describe various aspects of CANMET's Environment, Health and Safety research.

SUPPORTING DOCUMENTS

Annual report of Elliot Lake Centre - Information modules on:

- Sputum cytology
- Introduction to radiation
- Radiation in the home

TITLE: Determine radon emanation rates in underground uranium mines using backfill	FUNDING CANMET: \$30 200	PROGRAM: Minerals ACTIVITY: Mineral Technology Development
CONTRACTOR: Bondar Clegg and Co. Ltd.	CONTRACTOR:	
SCIENTIFIC AUTHORITY: K.C. Cheng	DSS:	SUB-ACTIVITY: Environment, Health and Safety
TEL: (705) 848-2236	OTHER:	SUB-SUB-ACTIVITY:
BEGIN/END: Sept. 1978 - June 1979		
REQUISITION NO.: 23440-8-9040	TOTAL: \$30 200	PROJECT:

OBJECTIVES

To measure and identify the radon emanation and radon daughters in the mining environment of a cut and fill uranium mine at various stages of the mining cycle for an evaluation on radiation conditions. Radon gases emanate into mine air from ore/rock surfaces, broken ore piles and backfill materials. They are the sources of radon daughters that pose health hazards to uranium mine workers. The identification of radon sources is a necessary step for better control of mine radiation.

PROCEDURE

The Lucas method was used for measuring radon gas and the Kusnetz method for measuring radon daughters. The analyses for uranium in ore and rock samples were done by X-ray fluorescence spectrometry. The radium analyses for water, ore, rock and backfill samples were done by track etched technique.

RESULTS

1) Radon emanation rates of Beaverlodge ore samples ranged from 1.3×10^{-17} to 6×10^{-16} Ci/cm²/s and that of waste rock samples from 5.4×10^{-19} to 1.34×10^{-17} Ci/cm²/s. The emanation rate of mine walls with ore to rock ratio of 1:7 was 6×10^{-17} Ci/cm²/s.

2) The mean equilibrium ratio between radon and its daughters at 15 active stopes was 31.5% or 0.315 W.L. per 100 pCi radon.

3) The peak of radon emanation profile during the cut and fill mining cycle occurred at backfilling operations as well as at daily shift-end blasting operations. Other mining activities such as mucking, drilling, etc have little effect on radon contamination of the ventilation air.

4) Backfill solution during backfilling rate of 100 t/h released approximately 1.8×10^6 pCi/min. of radon and elevated radon concentrations in stopes 2 to 5 times above the background levels. Under a normal ventilation condition, the background levels of radon concentration in C and F stopes were 25 to 45 pCi/l.

APPLICATION AND ONGOING WORK

The result pin-points the problem area, indicating that future programs should be directed to studies on radon emanation and control technique in relation to cement-adding backfills and blasting operations. The future work requires a continuous radon monitoring system.

SUPPORTING DOCUMENTS

Bondar-Clegg and Company Ltd. "Radon emanation rates in a cut and fill uranium mine"

MINERALS PROGRAM

EXPLOSIVES ACT

TITLE: Explosion hazards of ammonium nitrate (Year 2 of a 3-year contract)	FUNDING CANMET:	\$15 000	PROGRAM: Minerals
			ACTIVITY: Admin. of Canada Explosives Act
CONTRACTOR: Queen's University, Dept. of Mining Engineering	Transport Canada	\$5 000	
SCIENTIFIC AUTHORITY: J.A. Darling	Industry, Trade and Commerce	\$5 000	SUB-ACTIVITY: Authorization and Testing
TEL: 996-4570 Ext. 190	Canadian Fertilizer Inst.	<u>\$25 000</u>	SUB-SUB-ACTIVITY:
BEGIN/END: Jan. 1 - Dec. 31, 1978			
REQUISITION NO.: 23440-7-9080 (OSU77-00392)	TOTAL:	\$50 000	PROJECT:

OBJECTIVES

To investigate and report on the fire and explosion hazards of ammonium nitrate.

To study the conditions permitting detonation and the properties of detonating ammonium nitrate

To study the factors which can lead to detonation with particular attention to its behaviour in fires.

PROCEDURE

During this second year of the investigation the contractor determined the sensitivity to detonation of molten ammonium nitrate and calculated its Hugoniot properties.

The variation of sensitivity to detonation of ammonium nitrate prills with density was explored. Bulk trials were made with the densest product available.

RESULTS

Minimum primers for ammonium nitrate prills vary from 1 g at densities of 0.65 to 30 kg at densities of 0.90 to 0.97. Likewise, critical diameters vary from 50 mm to 3 m over the same range. Velocities of detonation in the range 3400 to 3800 m/s are possible in dense material.

Molten ammonium nitrate is sensitive to a No. 6 blasting cap. Card gap experiments indicate that at 280-300°C critical initiating pressures and critical particle velocities drop as low as 5 kilobars and 300 m/s respectively.

APPLICATION AND ONGOING WORK

Work is continuing to establish possible scenarios which explain accidental detonations of bulk samples of ammonium nitrate during fires.

SUPPORTING DOCUMENTS

- (a) Final report will be furnished after December 31, 1979.
- (b) Interim reports on file at CERL include:
 - (i) Critical review of EEC detonability test
 - (ii) Critical review of thermal decomposition mechanisms of ammonium nitrate
 - (iii) Priming test data for Canadian prills
 - (iv) Review of accidents with Ammonium Nitrate
 - (v) Detonation properties of liquid ammonium nitrate
 - (vi) Detonation properties of ammonium nitrate prills.

CANMET REPORTS

Recent CANMET reports presently available or soon to be released through Printing and Publishing, Supply and Services, Canada (addresses on inside front cover), or from CANMET Publications Office, 555 Booth Street, Ottawa, Ontario, K1A 0G1:

Les récents rapports de CANMET, qui sont présentement disponibles ou qui le seront bientôt peuvent être obtenus de la direction de l'Imprimerie et de l'Edition, Approvisionnements et Services Canada (adresses au verso de la page couverture), ou du Bureau de vente et distribution de CANMET, 555, rue Booth, Ottawa, Ontario, K1A 0G1:

- 79-23 Selection of ternary fused chlorides for the electrowinning of lead and zinc based on calculated thermodynamic properties; C.W. Bale, A.D. Pelton, W.J. Thompson and J.M. Skeaff;
Cat. No. M38-13/79-23, ISBN 0-660-10667-1; Price: \$3.25 Canada, \$3.90 other countries.
- 79-34 Recycling of steel plant waste oxides - A review; C.J. Adams;
Cat. No. M38-13/79-34, ISBN 0-660-10552-7; Price: \$1.50 Canada, \$1.80 other countries.
- 79-35 Reference materials - Rock samples SY-2, SY-3 and MRG-1; Sydney Abbey;
Cat. No. M38-13/79-35, ISBN 0-660-10611-6; Price: \$4.00 Canada, \$4.80 other countries.
- 79-38 Strength and freeze-thaw characteristics of concrete incorporating granulated blast furnace slag; V.M. Malhotra;
Cat. No. M38-13/79-38, ISBN 0-660-10577-2; Price: \$2.25 Canada, \$2.70 other countries.
- 79-39 Fluidized-bed combustion - An emerging technology; F.O. Friedrich;
Cat. No. M38-13/79-39, ISBN 0-660-10578-0; Price: \$2.00 Canada, \$2.40 other countries.
- 79-40 Comparisons of coke produced in different CANMET coke ovens - Part 2; J.T. Price and R. Leeder;
Cat. No. M38-13/79-40, ISBN 0-660-10590-X; Price: \$2.00 Canada, \$2.40 other countries.
- 79-41 Catalogue of CANMET publications 1978-79/Catalogue des publications de CANMET 1978-79;
Cat. No. M38-13/79-41, ISBN 0-660-50636-X; Price: \$18.50 Canada, \$22.20 other countries.
- 80-1E Sodium beta- and beta"-alumina ceramics: Powder preparation; D.J. Green and T.A. Wheat;
Cat. No. M38-13/80-1E, ISBN 0-660-10655-8; Price: \$2.95 Canada, \$3.55 other countries.
- 80-3E Petrography in the evaluation of aggregates and concretes; J.A. Soles;
Cat. No. M38-13/80-3E, ISBN 0-660-10591-8; Price: \$2.00 Canada, \$2.40 other countries.
- 80-4E Cokemaking with Canadian medium- and high-volatile commercial coking coals; J.F. Gransden, J.T. Price and W.R. Leeder;
Cat. No. M38-13/80-4E, ISBN 0-660-10571-3; Price: \$2.25 Canada, \$2.70 other countries.
- 80-5E Assessment of an expanded clay lightweight aggregate in structural concrete; H.S. Wilson;
Cat. No. M38-13/80-5E, ISBN 0-660-10612-4; Price: \$1.50 Canada, \$1.80 other countries.
- 80-6E Certified reference materials; H.F. Steger;
Cat. No. M38-13/80-6E, ISBN 0-660-10579-9; Price: \$2.25 Canada, \$2.70 other countries.
- 80-8 Metals terminology/La terminologie des métaux; André Blouin;
Cat. No. M38-13/80-8, ISBN 0-660-50586-X; Price: \$24.95 Canada, \$29.95 other countries.