

# CANMET

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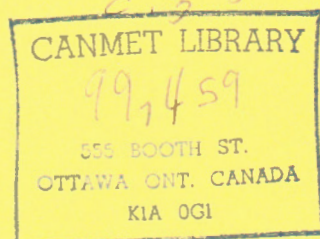
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**1977/78**  
**CATALOGUE OF CANMET PUBLICATIONS**

Publications and papers published or presented by  
CANMET scientific and technical staff in 1977/78.

ENERGY AND MINERALS RESEARCH PROGRAMS  
TECHNOLOGY INFORMATION DIVISION

CANMET REPORT 78-18

June 1979

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## FOREWORD

This catalogue and index were compiled for the purpose of presenting in concise form those publications and particular categories of papers published or presented by CANMET scientific and technical staff during fiscal 1977/78. It is intended that it will fulfill the important need for a useful, comprehensive reference source.

Section 1 lists, with abstracts, publications for general distribution and sold at prices indicated, through Printing and Publishing, Supply and Services Canada, Ottawa, K1A 0S9, or CANMET Publication Sales and Distribution, Energy, Mines and Resources Canada, 555 Booth Street, Ottawa, K1A 0G1.

Section 2 covers papers, with abstracts, either published in or submitted to outside periodicals or presented at various conferences. They are listed alphabetically by author and are designated numerically under the initials of originating program and laboratory or division, e.g., ERP/ERL (Energy Research Program/Energy Research Laboratories). Periodicals containing these papers are available in many libraries.

Section 3 lists divisional and program reports. These provide results of investigations performed at the request of industry or other government agencies, as well as results of investigations initiated by CANMET laboratories dealing with specific materials and processes. Also included are a number of bibliographic compilations and similar reports covering topics of interest to the general public. These reports are on open file and available for consultation at the CANMET Library, 555 Booth Street.

Section 4 contains a list of reports prepared by private research agencies under contract to CANMET dealing with studies on national mineral resources, energy supply and technology. These reports are on open file in microfiche form and are available at a prepaid cost of \$2.00 per microfiche (98 pages/frame) from Technology Information Division, CANMET, 555 Booth Street, Ottawa, K1A 0G1.

The index consists of two sections arranged alphabetically by author and subject respectively.

James E. Kanasy,  
Chief,  
Technology Information Division



## CONTENTS

	Page
FOREWORD . . . . .	1
SECTION 1 . . . . .	1
CANMET Reports . . . . .	1
SECTION 2 . . . . .	11
Papers published in or submitted to periodicals and presentations . . . . .	11
Mineral Sciences Laboratories . . . . .	11
Physical Metallurgy Research Laboratories . . . . .	20
Energy Research Laboratories . . . . .	22
Mining Research Laboratories . . . . .	25
Technology Information Division . . . . .	28
SECTION 3 . . . . .	29
Available laboratory, divisional and program reports . . . . .	29
Mineral Sciences Laboratories . . . . .	29
Physical Metallurgy Research Laboratories . . . . .	37
Energy Research Laboratories . . . . .	39
Mining Research Laboratories . . . . .	41
Energy Research Program . . . . .	43
Technology Information Division . . . . .	43
SECTION 4 . . . . .	45
Research agency reports . . . . .	45
AUTHOR INDEX . . . . .	51
SUBJECT INDEX . . . . .	55

## SECTION 1

### CANMET REPORTS

CANMET REPORT 77-4. Richards, D. and Stimpson, B. "Pit slope manual, Supplement 6-1, Buttresses and retaining walls"

This supplement to the Pit slope manual, Chapter 6, Mechanical support, describes how buttresses and retaining walls may be used to support open pit slopes. Also, the various methods of slope toe support and procedures for design and construction are given. Case histories of stabilization by a buttress at a Canadian mine and by retaining wall at a South African mine are provided. Cat. No. M38-14/6-1977-1 - 79 p  
Canada \$3.00; other countries \$3.60

CANMET REPORT 77-8. Hamza, H.A. and Picard, J.L. "Index of commercial flocculants - 1974"

This index assists in selecting a range of flocculants for laboratory evaluations to optimize solid-liquid separation applications. Bench tests can be reduced to a minimum by applying the principle of pre-screening.

Tabulations were compiled directly from manufacturers and technical bulletins, supplemented by additional data as reported in the literature or from bench-scale tests by CANMET's Western Research Laboratory. Cat. No. M38-13/77-8 - 27 p  
Canada \$1.00; other countries \$1.20

CANMET REPORT 77-9. Hamza, H.A. "Filtration - filters and filter media"

This is a detailed review of the application and operational aspects of the filtration process and outlines criteria that should be applied for selecting filters and filter media for various system and slurry characteristics.

Filters are classified according to mode of operation and the driving force employed to effect separation between solid and liquid. High rates of filtration are normally provided by high pressures and continuous operation, however, maximum pressures are often limited by mechanical design considerations and batch operation thus may be necessary. The report provides essential characteristics of the most common types of filters, stating advantages and disadvantages.

Various types of material used as filter media are also described and are ranked as to suitability for various applications. Criteria are presented for making a selection on the basis of physical properties - strength, binding, or cake discharge, chemical properties - resistance to chemicals, heat, etc. and constructional properties - types of yarn, fabric geometry, weave pattern, etc.

Cat. No. M38-13/77-9 - 75 p  
Canada \$2.00; other countries \$2.40

CANMET REPORT 77-10. Sawatzky, H., Ahmed, S.M., George, A.E. and Smiley, G.T. "Separation of nitrogenous materials from bitumen and heavy oils"

Separation of nitrogenous compounds and associated polar materials from deasphalted Athabasca bitumen was studied by modified API-USBM procedures. Application of the modified procedures was made to Cold Lake bitumen and to Lloydminster and Medicine River oils. A heavy oil product from a severely hydrocracked Athabasca bitumen was also studied.

Most of the neutral nitrogen compounds were obtained in the tail portions of the pentane and cyclohexane eluates, thus avoiding the cumbersome treatment with ferric chloride.

In the study of fractions separated from the bitumen and its hydrocracked products, infrared spectrometry showed practically complete decarboxylation of carboxylic acids and the apparent large increase in carbazoles and indoles during hydrocracking.

Cat. No. M38-13/77-10 - 20 p  
Canada \$1.00; other countries \$1.20

CANMET REPORT 77-11. Mathieu, G.I. "Ozonation for destruction of cyanide in Canadian gold mill effluents - A preliminary evaluation"

A literature search was made to determine whether ozonation would be technically and economically attractive for treatment of cyanide-bearing gold mill effluents. This state-of-the-art review shows that ozonation might be a valid alternative to conventional methods of cyanide detoxification. The ozonation process is relatively high in capital cost but low in operating cost compared with conventional processes.

Cat. No. M38-13/77-11 - 40 p  
Canada \$1.50; other countries \$1.80

CANMET REPORT 77-12. Gyenge, M. and Herget, G. "Pit slope manual, Chapter 3, Mechanical properties"

Slope stability analysis requires measuring material strengths by appropriate field and laboratory tests. Properties used in calculating forces and displacements, e.g., density and elastic modulus, must also be measured.

This chapter and its supplements (issued separately) guides the user on procedures required to ascertain the essential mechanical properties of soils and rocks of open pit wall structures. It also explains the necessity for certain data and information, and the tests required to obtain them.

Cat. No. M38-14/3-1977 - 87 p  
Canada \$3.50; other countries \$4.20



CANMET REPORT 77-13. Sharp, J.C., Ley, G.M.M., and Sage, R. "Pit slope manual, Chapter 4, Groundwater"

Groundwater is a significant operating factor in many open pit mines. This chapter outlines the principles of groundwater flow and describes how pressure influences shear strength of jointed rock masses. Practical aspects of groundwater control and principles and methods of effecting slope drainage are described.

The procedure is given for typical groundwater evaluation programs, relating various elements to the feasibility, mine design, and operating stages.

Case studies are provided, illustrating methods and techniques. Practical details of the techniques required are described separately in Appendices.

Cat. No. M38-14/4-1977 - 240 p  
Canada \$3.25; other countries \$3.90

CANMET REPORT 77-14. Calder, P. "Pit slope manual, Chapter 7, Perimeter blasting"

Perimeter blasting limits damage to final pit walls and benches by lowering explosive energy concentration at the pit perimeter, and by controlling energy concentration from the main production blast.

This chapter describes the various control blast techniques and gives the necessary procedures, tests, and technical details for developing optimal wall control procedure, based on site conditions at each stage of mine development. The steps required for reducing ground shock are outlined and current Canadian practice is summarized.

Cat. No. M38-14/7-1977 - 82 p  
Canada \$2.25; other countries \$2.70

CANMET REPORT 77-15. Larocque, G. "Pit slope manual, Chapter 8, Monitoring"

The objective of monitoring is to detect possible pit wall instability so that appropriate remedial measures can be taken for the protection of men and equipment. Monitoring takes place during the operating stage of mining. However, advance planning is essential, and the nature and location of monitors should be decided on during the design stage.

Recent improvements in monitoring instruments include the development of electro-optical distance measuring units for surface displacements and in telemetry - the remote reading of instruments by radio or cable.

This chapter presents monitoring in three levels - overall monitoring of walls, designed to locate areas of potential instability; detailed monitoring of potential instabilities; and monitoring of actual instabilities.

Cat. No. M38-14/8-1977 - 188 p  
Canada \$3.50; other countries \$4.20

CANMET REPORT 77-16. Major, G., Kim, H.S. and Ross-Brown, D. "Pit slope manual, Supplement 5-1, Plane shear analysis"

This supplement to the Pit slope manual chapter on Design provides feasible methods of analyzing slope instability arising from sliding

on discontinuities. A description of graphical methods is included.

Appendices provide documentation of the following computer programs: PLAFAM - for analyzing the single plane or stepped-path mode of instability; TWOBAM - for the analysis of two-block sliding; WINTAM - a 3-D wedge analysis program; GENSAM - general slip surface analysis and MONTEC - Monte Carlo subroutines that are used in all of the above stability programs.

Cat. No. M38-14/5-1977-1 - 307 p  
Canada \$4.25; other countries \$5.10

CANMET REPORT 77-17. Sage, R., Toews, N., Yu, Y. and Coates, D.F. "Pit slope manual, Supplement 5-2, Rotational shear sliding: Analyses and computer programs"

Instability by sliding on an approximately circular surface typically occurs in slopes in soft or ductile ground. The material must be sufficiently plastic to yield without excessive loss of strength. An approximate analysis suitable for hand calculation is provided; for more detailed analysis a computer program, SLOPROB, is described.

This requires the distribution of stresses in the slope as input. This distribution is best obtained by a finite element analysis; a suitable program, SAP2D, is described.

Cat. No. M38-14/5-1977-2 - 92 p  
Canada \$3.00; other countries \$3.60

CANMET REPORT 77-18. Cruden, D., Ramsden, J. and Herget, G. "Pit slope manual, Supplement 2-1, DISCODAT program package"

This supplement documents the major part of a system - DISCODAT - for analyzing observations of the characteristics of discontinuities in a rock mass - storage, retrieval, analysis and display of structural data. Card decks are supplied separately.

Cat. No. M38-14/2-1977-1 - 62 p  
Canada \$3.50; other countries \$4.20

CANMET REPORT 77-19. Ramsden, J., Cruden, D. and Herget, G. "Pit slope manual, Supplement 2-2, Domain analysis programs"

This report documents a User's Manual for the domain analysis of structural data. The analysis defines the orientation domains of a particular discontinuity. The procedure is divided into four stages and each is described in detail: file preparation and definition of groups; computation of group means and dispersions; display of group means and dispersions; definition of domains and characterization of domain subfabrics.

Cat. No. M38-14/2-1977-2 - 60 p  
Canada \$3.75; other countries \$4.50

CANMET REPORT 77-20. Khulbe, C.P., Pruden, B.B., Denis, J.M. and Merrill, W.H. "A pilot plant investigation of thermal hydrocracking of Athabasca bitumen: 2. Effect of recycle of heavy oil on product quality"

Studies were made of thermal hydrocracking in a bottom-feed reactor with recircula-

tion of a portion of the heavy-oil product (recycle run). A comparison of product quality for runs with and without recycle is made at similar experimental conditions of temperature, pressure, hydrogen gas flow and fresh feed flow. Reactor temperature had a marked effect on product yields, pitch conversion and sulphur removal, and a minor effect on product quality.

Cat. No. M38-13/77-20 — 41 p  
Canada \$1.50; other countries \$1.80

CANMET REPORT 77-21. Mirkovich, V.V. "An apparatus for measuring thermal diffusivity in air"

Two prototypes for measuring thermal diffusivity of solid materials in air are described. These prototypes, which are based on the concepts of an infinite cylinder and radial heat flow, are designed to measure thermal diffusivity in transitory and periodic temperature modes. Measurements performed on Pyroceram Code 9606 have shown that accurate data can be obtained in one of the experimental models between 25 and 700°C.

Cat. No. M38-13/77-21 — 28 p  
Canada \$1.25; other countries \$1.50

CANMET REPORT 77-22. Herget, G. "Pit slope manual, Supplement 2-3, Geophysics for open pit sites"

An overview is presented of surface and borehole geophysical methods useful in evaluating distribution of rock and soil types, and of rock fractures. For surface geophysics, do-it-yourself methods are described. Types of equipment are described and guidance is given in assessing possible benefits and costs of borehole logging.

Cat. No. M38-14/2-1977-3 — 25 p  
Canada \$1.00; other countries \$1.20

CANMET REPORT 77-23. Herget, G. "Pit slope manual, Supplement 2-4, Joint mapping by terrestrial photogrammetry"

Terrestrial photogrammetry can be used to obtain geological information on orientation, spacing and length of joints from steep rock slopes with limited access. This supplement, in serving as a guide to principles, accuracy, data collection, analysis and costs, is intended to encourage the use of terrestrial photogrammetry to its full potential. It will assist geologists in assessing the applicability of the technique to their objectives and will familiarize photogrammetric analysts with some aspects of geological discontinuity observation.

Cat. No. M38-14/2-1977-4 — 34 p  
Canada \$2.50; other countries \$3.00

CANMET REPORT 77-24. Martin, D., Piteau, D. and Herget, G. "Pit slope manual, Supplement 2-5, Structural geology case history"

A case history is described for the geological mapping of an iron ore pit. The study involved analysis of major discontinuities and joints to define structural domain boundaries and joint sets. Design sectors were delineated where slope geometry and structural geology are similar. Structural analysis included orientation, size,

spacing, waviness, rock hardness, and groundwater flow.

Cat. No. M38-14/2-1977-5 — 29 p  
Canada \$2.75; other countries \$3.30

CANMET REPORT 77-25. Gyenge, M. "Pit slope manual, Supplement 3-1, Laboratory classification tests"

Tests for physical properties, index properties and uniaxial strength of the rock substance are described. These tests are used for determining water content; porosity/density; swelling pressure index; swelling strain index; slake-durability index; uniaxial compressive strength; point load strength index; and tensile strength.

Cat. No. M38-14/3-1977-1 — 31 p  
Canada \$1.25; other countries \$1.50

CANMET REPORT 77-26. Gyenge, M. and Herget, G. "Pit slope manual, Supplement 3-2, Laboratory tests for design parameters"

This supplement describes tests to determine strength and elastic properties of rock substance and of discontinuities in rock, i.e., elastic modulus and Poisson's ratio from stress-strain measurements during uniaxial compression; ultrasonic elastic constants from measurements of sound velocity; triaxial compressive strength by loading a cylindrical sample axially and laterally; residual angle of friction of rock specimens from shear strength along a sawcut plane; discontinuity shear strengths by direct shear test and triaxial testing; strength properties of crushed rock by triaxial testing; and time dependent deformation and strength properties of rock specimens by long-term uniaxial compressive tests.

Cat. No. M38-14/3-1977-2 — 74 p  
Canada \$1.50; other countries \$1.80

CANMET REPORT 77-27. Gyenge, M. and Ladanyi, B. "Pit slope manual, Supplement 3-3, In situ field tests"

This supplement describes in situ tests to determine deformation and strength properties and to assist in classification and characterization of slope materials. Deformation modulus is determined by dilatometer tests in a borehole. In situ direct shear strength is determined by isolating a suitable specimen through sawing and drilling, and using in situ jacks to provide normal and horizontal forces. In situ density is determined by measuring the volume of an excavated hole and weighing the excavated material; it can also be determined from production blast holes by weighing drill cuttings.

Cat. No. M38-14/3-1977-3 — 17 p  
Canada \$1.25; other countries \$1.50

CANMET REPORT 77-28. Gyenge, M. and Ladanyi, B. "Pit slope manual, Supplement 3-4, Selected soil tests"

This supplement describes soil testing methods which can be used to test overburden materials, or soil-like materials which may be found in the form of gouge materials or highly altered



and weathered layers. Both laboratory and field tests are included. One is used for characterizing and classifying physical properties of soils and the others determine strength properties for stability analysis.

Cat. No. M38-14/3-1977-4 - 18 p  
Canada \$1.50; other countries \$1.80

CANMET REPORT 77-30. Marlon-Lambert, J. "Pit slope manual, Supplement 4-1, Computer analysis of groundwater seepage"

FEFPM (Finite Element Analysis of Flow in Porous Media) performs a steady-state seepage analysis to determine fluid pressures, flow quantities, rates and direction of groundwater slopes. It assumes either planar or radially symmetric flow, linear in a finite element in a porous medium. It computes the location of phreatic surface for unconfined flow problems, material type and permeability for a specific soil element, and fluid potential and stream function values. The program generates nodes and elements of a finite element mesh during iterations to locate a phreatic surface and automatically limits the flow regime to the slope profile.

Cat. No. M38-14/4-1977-1 - 97 p  
Canada \$3.50; other countries \$4.20

CANMET REPORT 77-31. Murray, D.R. "Pit slope manual, Supplement 10-1, Reclamation by vegetation: Vol 1 - Mine waste description and case histories"

This supplement explains how climate, waste properties, and microbial activity affect the establishment and growth of vegetation. An inventory of mining wastes forms an important part of this supplement. A procedure is described for examining a mine waste and determining its suitability to support a vegetative cover. Appendices provide case histories illustrating reclamation projects and problems encountered; climatic maps; and cost analyses.

Cat. No. M38-14/10-1977-1 - 120 p  
Canada \$3.50; other countries \$4.20

CANMET REPORT 77-32. Khulbe, C.P., Pruden, B.B., Denis, J.M. and Merrill, W.H. "Pilot plant thermal hydrocracking of GCOS (Great Canadian Oil Sands) bitumen 3. Effect of heavy-oil recycle on reactor fouling"

Thermal hydrocracking of Athabasca bitumen was carried out in a pilot-scale reactor at 13.9 MPa, liquid hourly space velocity 1, and at 450 and 460°C with recirculation of a portion of the heavy-oil product to the reactor bottom. The pilot plant was operated for 21- and 13-day runs to determine the effect of heavy-oil recirculation on deposition of solids in the reactor and hot separator. Deposition of solids was substantially reduced in both runs compared with once-through runs at same pitch conversion. This was attributed to a short "first pass" residence time and high ash content of the reactor fluid.

Cat. No. M38-13/77-32 - 18 p  
Canada \$1.00; other countries \$1.20

CANMET REPORT 77-33. Leeder, W.R. and Malette, M.J. "Hot briquetting study using western Canadian coal samples"

Preliminary hot briquetting studies were done on one coking coal from Fording Coal Limited and three non-coking coals from CanPac Minerals Limited. Comparative breakdown of results and conclusions are given.

Cat. No. M38-13/77-33 - 21 p  
Canada \$1.00; other countries \$1.20

CANMET REPORT 77-34. Kawatra, S.K. and Dalton, J.L. "X-ray fluorescence on-line analysis of lead-zinc ore fractions in mineral slurries - A comparison of wavelength-dispersive and energy-dispersive techniques"

Wavelength- and energy-dispersive X-ray fluorescence analysis techniques were simultaneously compared, using a slurry recirculation system consisting of a gamma-ray density gauge and flow cells attached to an X-ray tube excitation-wavelength dispersive system, and an isotope-excitation-energy dispersive system. It was found that the energy dispersive system which is less expensive than a wavelength dispersive system, gives acceptable results for mill control purposes.

Cat. No. M38-13/77-34 - 21 p  
Canada \$1.00; other countries \$1.20

CANMET REPORT 77-35. Khulbe, C.P., Pruden, B.B. and Denis, J.M. "Hydrocracking of Athabasca bitumen: Effect of coal-base catalyst on pilot plant operation"

Pilot plant experiments are described using a coal-base catalyst, consisting of a "coke getter" (high volatile A coal) coated with a desulphurization catalyst (Co-Mo-alumina, 15 wt % of the coal), in hydrocracking Athabasca bitumen. The slurry of bitumen and 2% coal-base catalyst was pumped into the bottom of a 4.5-L reactor, 3.8 cm dia and 4 m long, at 460°C and 13.89 MPa pressure. A system pressure drop of less than 0.4 MPa occurred and after 21 days the hot separator, preheaters and all transfer lines were clean but the reactor contained a hard porous deposit 3 m long. Although hydrogen consumption was higher with catalyst, more coke deposition occurred. Increased reactor coking was likely due to the low melting point of coal resulting in high ash content. Sulphur removal was higher than without additive. No problems occurred with additional hydrogen sulphide gas.

Cat. No. M38-13/77-35 - 22 p  
Canada \$1.00; other countries \$1.20

CANMET REPORT 77-36. Shah, A.M., Pruden, B.B. and Denis, J.M. "Thermal hydrocracking of Athabasca bitumen: Effect of recycle-gas purity on product yields and qualities"

Thermal hydrocracking of Athabasca bitumen at 13.89 MPa and 450°C was investigated employing a liquid hourly space velocity of 1 and a recycle-gas gas rate of 0.0425 m<sup>3</sup>/h at the system pressure and 20°C. The experiments were conducted

in a 4.5-L reactor with the recycle-gas purity in the range of 60-96 vol % H<sub>2</sub>. The hydrogen partial pressure in the reactor was between 7 and 12 MPa. The most significant finding was that industrial hydrogen streams with 60-85 vol % H<sub>2</sub> could be used without purification in the preliminary refining of Athabasca bitumen with a reduction in process costs.

Cat. No. M38-13/77-36 — 28 p

Canada \$1.25; other countries \$1.50

CANMET REPORT 77-37. Ranganathan, R., Pruden, B.B., Ternan, M. and Denis, J.M. "Evaluation of two-stage thermal and catalytic hydrocracking process for Athabasca bitumen"

A two-stage thermal and catalytic hydrocracking process for upgrading Athabasca bitumen is described. In the thermal stage, bitumen is treated with excess hydrogen in a tubular reactor at 13.90 MPa and 450°C. In the catalytic stage, at 13.90 MPa and 430°C, results suggest that specifications of reformer naphtha feedstock, fuel oils and cat-cracking gas-oil feedstock can be met. Three catalysts, Co-Mo on alumina, Ni-Mo on alumina and Ni-W on alumina are evaluated in the catalytic stage and their selectivities compared.

Cat. No. M38-13/77-37 — 17 p

Canada \$1.00; other countries \$1.20

CANMET REPORT 77-38. Campbell, W.P. "Comparison of notch-ductility and weldability of three high-strength structural steels"

A comparative study was made of the tensile, Charpy V-notch, and drop-weight properties of prime plate and welds in commercially produced T-1 and CHT-100 steels and in an experimental Cu-Ni steel. Comparison was also made of the cold-cracking behaviour of weld heat-affected zones in the three steels and of the behaviour of welds in explosion-bulge tests. Confirmatory crack-starter explosion-bulge tests were made on the Cu-Ni prime plate. The three steels showed no tendency to crack in controlled thermal severity tests, but cracked severely in Y-groove butt weld restraint tests unless preheated. The Cu-Ni and CHT-100 steels required a slightly higher preheat level than did the T-1 steel to eliminate cracking.

Cat. No. M38-13/77-38 — 68 p

Canada \$2.00; other countries \$2.40

CANMET REPORT 77-39. Bieffer, G.J. "The environmental cracking susceptibilities of three high-strength alloy steels"

Notched, fatigue pre-cracked specimens of three high-strength alloy steels (T-1, CHT-100 and 1% Cu-3.5% Ni), with yield strengths of about 690 MPa (100 ksi), were tested for susceptibility to environmental cracking. The specimens were loaded to fracture as cantilevers, using a rising-load technique. Susceptibility was assessed by comparing the nominal stress intensity at fracture under dry conditions, K<sub>Ii</sub> (dry), with the value obtained for specimens fractured in contact with 3.5% NaCl solution. The latter specimens were tested under free-corrosion conditions and also while cathodically protected by coupling to zinc.

It is concluded that these steels would be susceptible to EC, particularly in or near the welds, in severe hydrogen-embrittling applications and so should be tested thoroughly in both field and laboratory before using.

Cat. No. M38-13/77-39 — 19 p

Canada \$1.00; other countries \$1.20

CANMET REPORT 77-40. Ranganathan, R., Logie, R.B. and Denis, J.M. "Catalytic hydrocracking of Athabasca bitumen in a fluidized-bed reactor — Effect of pressure on catalyst decay"

This report describes the effect of pressure on catalyst decay when hydrocracking Athabasca bitumen in a fluidized-bed reactor. A cobalt-molybdenum catalyst (Nalco 471, 60-140 mesh, 3.2 wt % CoO-12.5 wt % MoO<sub>3</sub>/alumina) was evaluated. A stage of rapid, followed by a stage of slow deactivation occurred. These stages can be fitted to a linear equation for slow deactivation and an exponential equation for rapid deactivation. The results of the experiment are shown to be reproducible. A qualitative discussion comparing catalyst deactivation in fixed fluidized-bed reactors is given.

Cat. No. M38-13/77-40 — 22 p

Canada \$1.00; other countries \$1.20

CANMET REPORT 77-41. Herget, G. "Pit slope manual, Chapter 2, Structural geology"

This chapter provides guidance for site investigations of open pits, and for analyzing and presenting information for pit slope design. Methods of gathering and evaluating geological data, and a description of work requirements during mine operations are given. Time requirements and costs are provided to assist planning of various activities in mine development.

Cat. No. M38-14/2-1977 — 123 p

Canada \$3.50; other countries \$4.20

CANMET REPORT 77-42. Sawatzky, H., George, A.E., Banerjee, R.C., Smiley, G.T. and Montgomery, D.S. "Maturation studies on Canadian east coast oils"

Five Canadian east coast Cretaceous oils, were chemically investigated to establish their degree of thermal maturation. Chromatographic results, optical activity data and gasoline content categorize Heron and Adolphus oils as geochemically immature and Sable Island, Cohasset and Primrose as mature.

Cat. No. M38-13/77-42 — 15 p

Canada \$1.00; other countries \$1.20

CANMET REPORT 77-43. Belinko, K. and Denis, J.M. "A review of some chemical aspects of the formation of coke during thermal hydrocracking of bitumen"

Reaction mechanisms leading to coke formation during thermal hydrocracking of bitumen are discussed. The presence of two structurally different cokes is attributed to differences in coking properties of asphaltenes and heavy aromatic oils of the bitumen. Chemical structure of asphaltenes and heavy oils is reviewed to estab-



blish some relationship between their structure and type of coke formed after carbonization.

Cat. No. M38-13/77-43 - 13 p

Canada \$1.00; other countries \$1.20

CANMET REPORT 77-44. Shah, A.M., Pruden, B.B. and Denis, J.M. "Thermal hydrocracking of Athabasca bitumen: steady-state effects on product yields and qualities in the absence of scrubbing of the recycle gas"

Thermal hydrocracking of Athabasca bitumen at 13.89 MPa was investigated without scrubbing the recycle gas in a 3.8-cm ID x 4-m long reactor at 445 and 450°C, liquid hourly space velocities 1 and 2, and recycle hydrogen gas rates 0.0388 and 0.0425 m<sup>3</sup>/h at system pressure and 20°C. At LHSV of 2, 3 to 4 hours were required for the recycle gas purity to stabilize at constant values of 73.5% and 71.5% hydrogen at 445°C and 450°C respectively. However, at LHSV of 1 and 450°C, 10 to 12 hours were required to attain a constant recycle gas purity of 62.6% H<sub>2</sub>. When the recycle gas purity reached a constant value of 62.6% H<sub>2</sub>, operating time had no effect on the product yields and gaseous and liquid products of consistent quality were obtained.

Cat. No. M38-13/77-44 - 23 p

Canada \$1.00; other countries \$1.20

CANMET REPORT 77-45. Bieffer, G.J. "Exploratory corrosion tests in the Canadian Arctic"

This report summarizes results of a limited number of sea-water and atmospheric corrosion tests made in the Arctic on grade B structural and alloy steels and results are compared with behaviour in southern Canada.

Information on corrosivity of Arctic environments would be expected to aid in selecting metals, alloys and anti-corrosion systems in Arctic installations and vehicles.

Cat. No. M38-13/77-45 - 30 p

Canada \$1.00; other countries \$1.20

CANMET REPORT 77-46. Leeder, W.R. and Price, J.T. "Comparisons of coke produced in different CANMET coke ovens: Part 1: 12- and 18-inch oven coke strengths"

This report summarizes and gives regression analyses on tests carried out in 12-, 18-in. and Koppers technical-scale movable-wall ovens using similar coking coals or blends to compare quality of coke produced. Different standard conditions were used to produce coke similar to industrial coke ovens. Cokes produced from the same coal blend but carbonized in different ovens were found to have similar ASTM stabilities. The ASTM hardness values were similar for cokes from the Koppers and 12-in. ovens but these values were consistently higher than hardnesses for cokes from the 18-in. oven.

Cat. No. M38-13/77-46 - 18 p

Canada \$1.25; other countries \$1.50

CANMET REPORT 77-47. Leeder, W.R. and Jonasson, K.A. "Statistical correlation of ASTM and JIS coke tumbler test results"

CANMET's Coal Resource and Processing Laboratory (CRPL) has accumulated an extensive file of ASTM and JIS, coke tumbler test results using coke obtained from single technical-scale coke oven tests. The parallel ASTM stability and CRPL modified JIS DI<sub>15</sub><sup>30</sup> or DI<sub>15</sub><sup>50</sup> coke quality indices are compared graphically and correlated using regression analysis. It is concluded that the JIS drum test at 30 revolutions is inadequate and that the test should be carried out by the JIS method at 150 revolutions.

Cat. No. M38-13/77-47 - 32 p

Canada \$1.25; other countries \$1.50

CANMET REPORT 77-48. Shah, A.M., Pruden, B.B. and Denis, J.M. "Thermal hydrocracking of Athabasca bitumen: correlation of reactor voidage in vertical two-phase flow"

Pilot-plant experiments were carried out to determine the reactor voidage in vertical two-phase flow of hydrogen and Athabasca bitumen at various operating conditions of temperature, pressure, liquid feed rate and recycle gas rate. These conditions are within the range at which thermal hydrocracking takes place.

The linear relationship between the reactor voidage and the superficial gas velocity, V<sub>G</sub>, was found to apply. The value of the slope depended on the reactor geometry and experimental conditions. The superficial liquid velocity V<sub>L</sub> had no appreciable effect on slope for the system at 13.89 MPa and 400°C in a tubular reactor, however, the voidage increased with increased V<sub>L</sub> at constant V<sub>G</sub> in an annular reactor.

Investigation in a tubular reactor of kerosene and hydrogen at room temperature and different pressures and of water and nitrogen at room temperature and atmospheric pressure also indicated a linear relation between voidage and superficial gas velocity. The superficial liquid velocity did not have any effect on voidage in either case and the pressure dependency for kerosene-hydrogen system was similar to that observed for hydrogen-bitumen.

Cat. No. M38-13/77-48 - 33 p

Canada \$1.25; other countries \$1.50

CANMET REPORT 77-49. Quon, D.H.H. and Malhotra V.M. "Effect of elevated temperatures on compressive strength, pulse velocity and conversion of high alumina cement concrete"

High alumina cement has suffered structural failure in England. An investigation was undertaken to obtain data on test specimens cured at temperatures from 21 to 66°C under both humid and dry conditions, in periods ranging from 1 to 180 days.

The change in compressive strength of high alumina cement concrete with age followed the established pattern. The strength reached a maximum value followed by a minimum, then slowly increased with age. Cylinders exposed to dry heat at 66°C, after following the usual pattern of strength development with age continued to lose strength.

The rate of conversion of high alumina cement concrete, from hexagonal hydrates to cubic hydrates is a function of the temperature irres-

pective of the water/cement ratio. The rate of conversion also appears to be independent of the type of exposure, dry heat or immersion in water.

There is no correlation between the degree of conversion and compressive strength of high alumina cement concrete so that, it cannot be used as a measure of compressive strength.

The pulse velocity technique appears to be an excellent means of monitoring the long-term changes in compressive strength due to conversion in high alumina cement concrete. Its use to determine absolute values of strength cannot be recommended.

X-ray diffraction studies and scanning electron photomicrographs were shown to provide useful supporting data in the investigation of conversion phenomena.

Cat. No. M38-13/77-49 - 58 p

Canada \$2.25; other countries \$2.70

CANMET REPORT 77-50. Herrmann, W.A.O., Mysak, L.P. and Belinko, K. "A comparative study of Fe catalysts,  $ZnCl_2$  catalysts and  $ZnCl_2$ -promoted Fe catalysts for hydrocracking of Athabasca bitumen"

Autoclave experiments are described which show that catalysts for thermal hydrocracking of Athabasca bitumen can be produced from inexpensive Canadian raw materials. Iron (Class I) and zinc chloride-promoted catalysts (Class II) were investigated.

Products obtained were analyzed and compared with those using two conventional catalysts and with no catalyst. Highest conversion was achieved with an Fe-lignite catalyst. The next most active was 100%  $ZnCl_2$ . The latter produced a smaller amount of HC gas and significantly less sulphur in the product.

Cat. No. M38-13/77-50 - 21 p

Canada \$0.75; other countries \$0.90

CANMET REPORT 77-51. Belinko, K., Nandi, B.N. and Denis, J.M. "Analysis of reactor samples collected during thermal hydrocracking of Athabasca bitumen"

Samples from five reactor levels collected during thermal hydrocracking of Athabasca bitumen were analyzed for asphaltenes, benzene-insolubles and other components. Data indicated a conversion of asphaltenes to benzene-insoluble organic matter occurred during the process. Accumulated nickel and vanadium at the bottom of the reactor did not appear to have any significant effect on product quality.

Optical microscopic investigations revealed that benzene-insoluble matter from all reactor levels consisted primarily of coke derived from the asphaltenes. There was no evidence of coke originating from the heavy aromatic oils.

Cat. No. M38-13/77-51 - 26 p

Canada \$1.00; other countries \$1.20

CANMET REPORT 77-52. "CANMET review (formerly Mines memo) - Activities during 1976-77"

CANMET contributes to the department's Minerals and Energy Programs by: performing, contracting and coordinating research on mining,

extraction, utilization and conservation of minerals, metals and fuels and related environmental problems; providing a technical knowledge base as an aid for developing federal policies and plans; disseminating advanced technology information to public, government agencies, industry, researchers and technologists throughout Canada.

The matrix management system introduced in 1975 is now firmly established. Activities are planned and implemented through two programs - Minerals Research and Energy Research, operating six functional units.

In 1976-77, significant financial and personnel resources were shifted from the Minerals Research Program to the Energy Research Program to meet a more adequate response to national needs and economic imperatives.

This review presents highlights of the various activities and projects undertaken by two programs during 1976-77.

Cat. No. M31-12/1976 - 48 p

Canada \$2.00; other countries \$2.40

CANMET REPORT 77-53. Moffett, D., Zahary, G., Campbell, M.C. and Ingles, J.C. "CANMET's environmental and process research on uranium"

Much of the research on uranium tailings conducted at Elliot Lake for more than five years has been on rehabilitating pyritic tailings, resulting in a practicable technology for supporting vegetation. A program aimed at identifying and reducing acidic and radioactive effluents is also underway.

This report outlines research relating to the processing of uranium and thorium ores. A process was developed for recovering thorium thereby reducing the overall radioactive load in the tailings. Efforts are currently being made to develop technology for recovering uranium from lower grade ores and to remove pyrite, preconcentrate radioactive minerals and identify and remove chemical compounds that carry radium in solid tailings.

Cat. No. M38-13/77-53 - 29 p

Canada \$1.00; other countries \$1.20

CANMET REPORT 77-54. Hamer, C.A. "Acid extraction processes for non-bauxite alumina materials"

A number of acid extraction processes for recovering alumina from non-bauxite materials are reviewed from strictly technical considerations. The variety of processes differ in their approach to removing impurities and in the method of recovering and treating the hydrated aluminum salts.

Comments are made on acid processes for the principal potential Canadian non-bauxite sources, i.e., anorthosite, high alumina-containing coal wastes and low grade clays.

Cat. No. M38-13/77-54 - 41 p

Canada \$1.50; other countries \$1.80

CANMET REPORT 77-55. Collings, R.K. "Mineral waste resources of Canada Report No. 2 - Mining wastes in Quebec"

This report provides background infor-

mation on waste rock and mill tailings in Quebec which annually produces about 140 million tons. Data on the occurrence, mineralogy, physical and chemical characteristics of wastes from 33 operating mines are provided in tabular form for the four principal types of mines - base metals, iron ore, precious metals and industrial minerals. Potential uses for certain wastes are noted along with relevant research. Current applications include road construction and maintenance, railroad ballast, smelter flux and mine backfill. Other uses being studied by researchers within and outside CANMET include the recovery of contained metal and minerals, the production of concrete and construction aggregate, the manufacture of bricks, blocks and mineral wool insulation, and as a soil additive or neutralizer.

Cat. No. M38-13/77-55 - 45 p

Canada \$1.75; other countries \$2.10

CANMET REPORT 77-56. Fines, H., Slater, W. and Sage, R. "Corrosion protection and lateral displacement characteristics of rock anchors"

Rock anchors have good potential application in stabilizing open pit slopes. Corrosion resistance was examined by studying greased, polyethylene-sheathed strand. It was concluded this type of strand should be adopted where good corrosion resistance is required. Information is given and recommendations made for corrosion protection of rock anchors for use in mining. Laboratory tests are described for determining the effect of lateral displacement on the strength of rock anchors.

Cat. No. M38-13/77-56 - 28 p

Canada \$1.25; other countries \$1.50

CANMET REPORT 77-57. Mason, G.L. and Bowman, W.S. "Blast furnace slag SL-1: Its preparation for use as a certified reference material"

A Canadian blast furnace slag has been prepared as a compositional reference material, as part of the Canadian Certified Reference Materials Project.

Twenty-one participating laboratories provided analytical results for up to 13 constituents for each to two samples. A statistical treatment of the data yielded recommended values for six of these constituents: CaO - 37.5%, SiO<sub>2</sub> - 35.7%, MgO - 12.3%, Al<sub>2</sub>O<sub>3</sub> - 9.6%, Fe (expressed as FeO) - 0.9% and S - 1.26%. Four others were assigned provisional values: TiO<sub>2</sub> - 0.38%, MnO - 0.86%, Na<sub>2</sub>O - 0.39% and K<sub>2</sub>O - 0.51%.

Cat. No. M38-13/77-57 - 30 p

Canada \$1.25; other countries \$1.50

CANMET REPORT 77-58. Murray, D.R. "Pit slope manual, Supplement 10-1, Reclamation by vegetation: Vol 2 - Mine waste inventory by satellite imagery"

This supplement includes results from a survey of Canadian mine wastes using LANDSAT satellite imagery where more than 700 mine sites were examined. The wastes are classified as overburden, rock and tailings. The degree of vegetation cover on back site is estimated.

Cat. No. M38-14/10-1977-1-2 - 216 p

Canada \$4.25; other countries \$5.10

CANMET REPORT 77-59. McGrath, J.T. "Literature review on fracture toughness testing of the heat-affected-zone"

This report reviews methods available for evaluating fracture toughness of the heat-affected-zone (HAZ). The following are discussed: HAZ fracture - whether fracture toughness should be based on crack initiation or propagation; selection of fracture toughness test specimens; examples of HAZ fracture toughness measurement; selection of fracture initiation criteria - assessment of the K<sub>IC</sub>, COD, I<sub>IC</sub> and K<sub>ID</sub> approaches; assessment of the Charpy test in HAZ fracture toughness evaluation; application of laboratory fracture toughness data in predicting structural failure.

A breakdown of costs of the various techniques is given.

Cat. No. M38-13/77-59 - 48 p

Canada \$1.75; other countries \$2.10

CANMET REPORT 77-60. Reeve, D.A., Price, J.T. and Gransden, J.F. "High-temperature behaviour of blast furnace coke - A review"

Studies of tuyere coke and coke samples taken from quenched blast furnaces have shown that cokes degrade primarily by chemical reaction with alkalis and CO<sub>2</sub> at temperatures above 900°C, rather than by physical abrasion. Methods reviewed include: simulation of coke oxidation at the tuyeres; hot strength of cokes at 1300 and 1500°C; reactivity of coke to CO<sub>2</sub> at 1100°C; and cold coke strength (after reaction with CO<sub>2</sub> at 1100°C). Coke strength was found to be lower at high temperatures than at room temperature. No correlation existed between hot-and-cold-strength tests. Mosaic structures of coke were less reactive to CO<sub>2</sub> than coke particles derived from inert coal macerals.

Cat. No. M38-13/77-60 - 25 p

Canada \$1.25; other countries \$1.50

CANMET REPORT 77-61. Makhija, R., Draper, R.G. and Furimsky, E. "Rapid method for determining sulphur and vanadium in petroleum products by non-dispersive X-ray fluorescence"

A method is described for simultaneous determination of sulphur and vanadium in petroleum products by non-dispersive X-ray fluorescence. Sulphur and vanadium can be determined in the ranges of 0.1 to 5.0% and 20 to 4000 ppm, respectively. The method is suitable for all relatively homogeneous petroleum fractions and residuums, including solid pitches. Preliminary results show that titanium can be analyzed in addition to sulphur and vanadium.

Cat. No. M38-13/77-61 - 21 p

Canada \$1.00; other countries \$1.20

CANMET REPORT 77-63. Faye, G.H., Bowman, W.S. and Sutarno, R. "Antimony-arsenic ore CD-1 - A certified reference material"

CD-1, an antimony ore, was prepared as a compositional reference material as part of the Canadian Certified Reference Materials Project. Approximately 270 kg of raw ore was dry-ground to - 74  $\mu\text{m}$ , blended, tested for homogeneity by X-ray fluorescence and chemical methods and bottled in 200-g units.

Twenty participating laboratories provided analytical results for antimony and arsenic for each of two samples. A statistical treatment of the data yielded recommended values for the two constituents: antimony - 3.5% and arsenic - 0.66%.

Cat. No. M38-13/77-63 - 11 p  
Canada \$1.00; other countries \$1.20

CANMET REPORT 77-64. Ingles, J.C., Sutarno, R., Bowman, W.S. and Faye, G.H. "Radioactive ores DH-1, DL-1, BL-1, BL-2, BL-3 and BL-4 - Certified reference materials"

A set of six radioactive ores was prepared and characterized as certified reference materials in chemical and radiometric analysis.

The set represents two series: ore and waste-grade material containing uranium and thorium from Elliot Lake, Ontario; and essentially thorium-free material from Beaverlodge, Saskatchewan.

Recommended values for uranium in DH-1, DL-1, BL-1, BL-2, BL-3 and BL-4 are: 0.177, 0.0041, 0.022, 0.453, 1.02 and 0.173%; for thorium in DH-1, DL-1 and BL-1 - 0.104%, 83 ppm (83  $\mu\text{g/g}$ ) and 15 ppm (15  $\mu\text{g/g}$ ).

Cat. No. M38-13/77-64 - 45 p  
Canada \$1.75; other countries \$2.10

CANMET REPORT 77-65. Malhotra, V.M. and Malanka, D. "Performance of superplasticizers in concrete: laboratory investigation - Part I"

Results are given of an investigation to determine the performance of superplasticizers in high-strength concrete with a water-cement ratio of 0.42. Superplasticizers are more expensive than ordinary water reducers and are thus not economical for use in every-day concrete; they are ideal where flowing concretes with very low water-cement ratios are required.

Cat. No. M38-13/77-65 - 47 p  
Canada \$1.75; other countries \$2.10

CANMET REPORT 78-2. Faye, G.H. and Bowman, W.S. "Revision of recommended values for reference ores MP-1 and KC-1"

Composition of Canadian Certified Reference Materials Project ores MP-1 and KC-1 has altered by oxidation since original certification in 1972 and 1974.

A program to recertify them results from 10 independent analysts indicated that the new means and corresponding 95% confidence intervals for zinc were  $15.90 \pm 0.06\%$  and  $20.07 \pm 0.07\%$  for MP-1 and KC-1.

Cat. No. M38-13/78-2 - 8 p  
Canada \$1.00; other countries \$1.20





## SECTION 2

PAPERS PUBLISHED IN OR SUBMITTED TO PERIODICALS  
AND PRESENTATIONS

## MINERAL SCIENCES LABORATORIES

Berry, E.E. "Production, use and properties of fly ash in Canada - Progress report"; MRP/MSL 77-95(OP); presented Ind Miner Div, 79th Ann Gen Meet, CIM, Ottawa; Apr. 17-21, 1977.

This paper examines fly ash use or potential use in concrete by the construction industry. It is estimated that 10% of the regional cement production capacity represents an upper limit to the potential market for fly ash in any one area, as a replacement for or supplement to cement. Some results are given from an examination of fly ash properties from all-Canadian sources.

Berry, E.E., Soles, J.A. and Malhotra, V.M. "Leaching of sulphur and calcium from sulphur-infiltrated concrete by alkaline and neutral aqueous media"; MRP/MSL 76-235(J); Cement Concr Res; 7:185-190; 1977.

Recent observations are presented which confirm the presence of polysulphide ions in aqueous solutions in contact with sulphur-infiltrated concrete.

Bruce, R.W. and Petruk, W. "Investigations on the effect of grinding media on the selective flotation of a zinc-copper ore from Mattagami Lake Mines Limited"; MRP/MSL 77-256(OP); abstract presented 16th Ann Conf Metallurgists, Aug. 23, 1977.

Pilot plant tests were performed on 200 tons of ore from Mattagami Lake Mines Limited and the mill products were analyzed with an image analyzer.

Cabri, L.J. "Determination of ideal formulae for new minerals of the platinum-group"; MRP/MSL 77-176(OP); abstract presented GSA Ann Meet; Nov. 1977.

Correct assignment of stoichiometry of newly reported species and varieties of platinum-group minerals may be made by careful consideration of crystallographic, synthesis, microanalysis, and density data.

Cabri, L.J. "The future economic significance of large low-grade copper and nickel deposits - book review"; MRP/MSL 76-224(J); Tsch Mineral Petrog Mitt; 24:123-124; 1977.

This book was found to suffer from delay in publication, ambiguities and inconsistencies in

data, making inadequate emphasis of the importance of mineralogy in evaluating low-grade nickel deposits.

Cabri, L.J., Rosenzweig, A. and Pinch, W.W. "Platinum-group minerals from Onverwacht. I. Pt-Fe-Cu-Ni alloys"; MRP/MSL 77-11(J); Can Mineral; 15:380-384; 1977.

Ferroan platinum and two different types of Pt-Fe-Cu-Ni alloys were found to occur in a sample from the former Onverwacht mine, Transvaal. Methods used and conclusions are given.

Cabri, L.J., Clark, A.M. and Chen, T.T. "Arsenopalladinite from Itabira, Brazil, and from the Stillwater complex, Montana"; MRP/MSL 76-214(J); Can Mineral; 15:70-73; 1977.

A re-examination was made of arsenopalladinite and of antimonian and stannian "stillwaterite" from the type locality which clarifies the relationship between the minerals. X-ray powder data are reported for arsenopalladinite from both localities.

Cabri, L.J., Stewart, J.M., Laflamme, J.H.G. and Szymanski, J.T. "Platinum-group minerals from Onverwacht. III. Genkinite,  $(Pt,Pd)_4Sb_3$ , A new mineral"; MRP/MSL 77-19(J); Can Mineral; 15:382-389; 1977.

A new mineral, genkinite  $(Pt,Pd)_4Sb_3$ , was found in a sample from the former Onverwacht mine, Transvaal.

Carson, D.W. "A novel method of Mössbauer data calibration using a laser interferometer"; MRP/MSL 76-195(TR); Nucl Instru Meth; 145:359-360; 1977.

A new method is described of data reduction using laser information and Mössbauer data to create a new Mössbauer data matrix where each channel has a discrete velocity in mm/sec and is separated from adjacent channels by a constant velocity difference.

Collings, R.K. "Mineral waste - asset or liability"; MRP/MSL 77-264(OPJ); presented Min and Ind Waste Sem, Toronto, Oct. 13, 1977, and publication in Proc. sponsored by Ontario Ministry of Industry and Tourism.

This paper reviews the types of mineral wastes available in Canada, lists and briefly describes a number that have potential value, and notes possible uses and related research by CANMET and other organizations.

Donaldson, E.M. "Spectrophotometric determination of bismuth in concentrates and non-ferrous alloys by the iodide method after separations by diethyl-dithiocarbamate and xanthate extractions"; MRP/MSL 77-187(J); submitted Talanta; June 1977.

A method is described for determining 0.0001 - 1% of bismuth in copper, molybdenum, lead, zinc and nickel sulphide concentrates. The proposed method is also applicable to lead-, tin- and copper-base alloys.

Donaldson, E.M. "Spectrophotometric determination of arsenic in concentrates and copper-base alloys by the molybdenum blue method after separations by iron collection and xanthate extraction"; MRP/MSL 76-200(J); Talanta; 24:105-110; 1977.

A method for determining 0.0001 - 1% of arsenic in copper, nickel, molybdenum, lead and zinc concentrates is described. The proposed method is also applicable to copper-base alloys.

Donaldson, E.M. "Spectrophotometric determination of selenium in concentrates and high-purity copper metal with 3,3'-diaminobenzidine after separation by xanthate extraction"; MRP/MSL 76-315(J); Talanta; 24:441-445; 1977.

A method for determining 0.0001 - 0.10% of selenium in copper, nickel, molybdenum, lead and zinc sulphide concentrates is described. Although developed primarily for concentrates, it is also applicable to high-purity copper.

Dutrizac, J.E. "The reaction of titanium with sulphur vapour"; MRP/MSL 76-103(J); J Less Common Met; 51:283-303; 1977.

The kinetics of reaction of coupons of annealed and unannealed titanium with pure sulphur vapour were investigated by a thermogravimetric method between 450 and 550°C. The sulphurization kinetics for annealed titanium were parabolic and pseudoparabolic for unannealed titanium. The sulphurization process is discussed in terms of a reaction controlled by the diffusion of titanium through the thickening  $Ti_{1+x}S_2$  scale.

Farrell, D.M. "Infrared investigation of basic double carbonate hydrate minerals"; MRP/MSL 76-250(J); Can Mineral; 15:408-413; 1977.

The infrared spectra of dundasite, strontiodresserite, dresserite, and hydrodresserite was found to corroborate the occurrence of hydrogen bonding in the minerals. The hydroxyl groups are linked through H-bonds and the frequency of hydroxyl stretching vibrations indicates that the hydrogen bonds are of variable strength in the order given. Hydrogen bonding to the carbonate groups produces bicarbonate-like spectral behaviour. Vibrational evidence was also found to

exist for hydrogen-bond linkages of metal-oxygen units. Lattice water was detected in the minerals, but no definite evidence was found for water coordination through the formation of aquo complexes.

Faye, G.H. "Reference ores - packaged measures of precision and accuracy for analysts"; MRP/MSL 77-30(J); North Min; C12; Apr. 14, 1977.

The importance of, and necessity for, certified compositional reference materials (RM's) to meet the increasing needs of industrial commercial, and research laboratories is discussed. The origin and work of the Canadian Certified Reference Materials Project (CCRMP) is outlined briefly.

Faye, G.H. "Spectrophotometric method for assessing oxidation of chalcopyrite-bearing ores and concentrates"; MRP/MSL 77-215(J); Talanta; July 1977.

A method is described for assessing short-term oxidation in which chalcopyrite-bearing ores, concentrates, etc. are agitated directly with an acetone-water solution of 2,2' biquinoline (biq) to form the Cu(I)-biq complex.

Flengas, S.N. and Dutrizac, J.E. "A new process for the separation of hafnium from zirconium"; MRP/MSL 77-244(J); Metall Trans; 88:377-385; 1977.

A new process for separating hafnium from zirconium is based on repeated reaction of mixed tetrachloride vapours of zirconium and hafnium with alkali metal chloride salts in either solid or liquid form. A theory of the separation process is explained. Possible commercial uses are also given.

Gilmore, A.J. "The recovery of zinc from a mine water containing small amounts of alkali and heavy metals"; MRP/MSL 76-196(OP); CIM Bull; 70: 142-146; 1977.

The chemical feasibility of producing a 91.1% ZnO product from a mine water by an ion exchange-precipitation technique is described. This technique illustrates its potential for: (1) in-plant recycling of clean process water, (2) achieving water-quality guidelines, (3) recovering soluble toxic metals from mine and other process waters, and (4) utilizing the product recovered.

Green, D.J. and Wheat, T.A. "Influence of process parameters and starting materials on the preparation of freeze-dried sodium beta-alumina"; ERP/MSL 77-286(OP); presented Basic Sci Div Am Ceram Soc, Hyannis, Mass.; Sept. 26-28, 1977.

As part of a wider program to examine ceramic solid state electrolytes for potential application in energy storage and conversion systems, the influences of starting materials and process variables in the production of beta"-alumina powders were studied. Factors such as composition, starting solution concentration, droplet

size, freeze-drying temperature and calcination technique were considered, particularly with respect to the presence of any beta-alumina in the final powder.

Green, D.J. and Wheat, T.A. "Synthesis of sodium beta"-alumina powder using a freeze-dry technique"; ERP/MSL 77-111(OP); presented Ann Meet, Am Ceram Soc, Chicago; April 1977.

Powders of fully converted Na  $\beta$ -Al<sub>2</sub>O<sub>3</sub> were prepared by a spray freeze-freeze dry technique. Contrary to other work, little or no evidence of Na  $\beta$ -Al<sub>2</sub>O<sub>3</sub> was found in the X-ray diffraction patterns of the calcined powders. These homogeneous powders have high surface areas (10-40 m<sup>2</sup>/g) and are prone to soda loss when calcined in air above ~1400°C and in argon at 10 psi above ~1300°C.

Hoey, G.R., Dingley, W. and Freeman, C. Corrosion behaviour of various steels in ore grinding"; MRP/MSL 76-211(J); CIM Bull; 70:778:105-109; 1977.

Information is provided on various steels for abrasion and corrosion resistance with and without inhibitors during grinding of Ni-Cu sulphide and hematite ores. Electro-chemical potential was measured and found useful for assessing susceptibility of an alloy to corrosion.

Hutchings, M.T., Townsend, M.G. and Webster, A.H. "Neutron diffraction investigation of the temperature variation of the sublattice magnetisation of nickel sulphide"; MRP/MSL 77-3(J); Sol State Comm; 22:123-126; 1977.

Single crystal neutron diffraction was used to measure the temperature variation of the sublattice magnetisation of antiferromagnetic Ni<sub>0.991</sub>S between 5K and the conductivity transition temperature 223K, T<sub>c</sub>, at which the ordered moment suddenly vanishes. The data cannot be explained consistently with those from other measurements using a localised-spin model, and support existing evidence that the antiferro-magnetism in NiS is due to itinerant electrons.

Jambor, J.L., Sabina, A.P. and Sturman, B.D. "Hydrodresserite, a new Ba-Al carbonate from silicocarbonatite sill, Montreal Island, Quebec"; MRP/MSL 76-344(J); Can Mineral; 15:399-404; 1977.

A description is given of the new mineral "hydrodresserite", BaAl<sub>2</sub>(CO<sub>3</sub>)<sub>2</sub>(OH)<sub>4</sub>·3H<sub>2</sub>O, which occurs in a silicocarbonatite sill, 2 m thick, exposed in a limestone quarry at St-Michel, Montreal Island. Data includes a breakdown of physical properties, optical and X-ray crystallography, chemical composition, and stability features. Approval has been given by the Commission on New Minerals and Mineral Names.

Jambor, J.L. and Beaulne, J.M. "Exploration possibilities for porphyry deposits in the central part of Highland Valley, British Columbia"; Geol Surv Can; Paper 77-1C:101-106; 1977.

The Highmont, Lornex and Valley Copper deposits were examined and sampled extensively during three field seasons to study mineralogy and hydrothermal alteration. This paper summarizes one aspect of a more detailed account (Jambor and Beaulne, in prep.) of the area.

Jambor, J.L. "Strontiodresserite, new Sr-Al carbonate from Montreal Island, Quebec"; MRP/MSL 77-135(J); Can Mineral; 15:405-407; 1977.

A description is given of the new mineral "strontiodresserite" which occurs in a silicocarbonatite sill, St-Michel, Montreal Island. Data include properties, composition, heating experiments, and comparisons with dresserite and dundasite. Approval has been given by the Commission on New Minerals and Mineral Names.

Joe, E.G. "Energy consumption in Canadian mills"; MRP/MSL 78-91(OP); presented Ann Gen Meet CIM; Apr. 23-27, 1978.

Results are provided from a survey of 67 Canadian mills to ascertain the scope and source of energy consumption. Copper and iron ore, representing the bulk of the tonnage, consumed relatively low levels of energy per ton. Nickel-copper, zinc-copper and lead-zinc ores consumed moderate levels, while uranium and some copper-lead-zinc mills consumed much higher levels because of increased heat requirements of the ore pulp.

Lakshmanan, V.I., Mackinnon, D.J. and Brannen, J.M.; "The effect of thiourea, LIX65N and chloride ion on the morphology of electrowon copper"; MRP/MSL 76-62(J); J Appl Electrochem; 7:127-133; 1977.

Deposit morphology was assessed by optical microscopy techniques, scanning electron microscopy and X-ray diffraction measurements. The importance of controlling the concentration of these additives in electrowinning copper from electrolytes obtained from a solvent extraction separation process is indicated.

Lakshmanan, V.I., Mackinnon, D.J. and Brannen, J.M. "The effect of chloride ion in the electrowinning of copper"; MRP/MSL 76-19(J); J App Electrochem; 7:81-90.

A systematic study of the influence of chloride ion on the morphology of copper deposits is described. This involved examining deposit cross-sections by optical microscope, determining crystal orientation by XRD methods and observing deposit surface in the scanning electron microscope.

Leclerc, A. and Townsend, G. "Ground state in FeS"; MRP/MSL 77-218(J); submitted J Phys Chem Sol; July 1977.

From a Mössbauer study of oriented single crystals of Fe<sub>0.996</sub>S and Fe<sub>0.93</sub>S at temperatures above T<sub>N</sub> (~598K), it is confirmed that the ground term in FeS is <sup>5</sup>E.



Lui, A.W. and Hoey, G.R. "Additives reduce ball wear in grinding low-grade copper ore"; MRP/MSL 76-252(J); Brit Corr J; 12:1:51-53; 1977.

Procedure is described for determining the effect of lime and silicate on corrosive wear of forged steel grinding balls during wet grinding of a low-grade copper ore between 25° and 65°C. Weight measurements of steel balls at various concentrations of additive in the ore slurries indicated that below pH 9.0, wear was affected by both pH and temperature; above pH 10.5, corrosive wear was prevented and abrasive wear was independent of temperature.

Lui, A.W. and Hoey, G.R. "Temperature and pH dependence of steel wear in grinding hematite ore"; MRP/MSL 76-269(J); Anti-Corr; 24:3:5-6; 1977.

The results of a study on the combined effect of temperature and pH on wear in grinding hematite ore are presented.

Lui, A.W. and Hoey, G.R. "Review of high-temperature metallic corrosion during chlorination of sulphides"; MRP/MSL 77-113(LS,OP); presented Conf Metall, Vancouver; Aug. 1977.

Corrosion behaviour of various metals and sulfidation are reviewed. Nickel, tantalum, zirconium and platinum were reported to possess good resistance to chlorination and under certain conditions, perform exceptionally well in chlorine atmospheres. On the other hand, certain iron alloys (e.g., Fe-5Al, Fe-5Cr), and molybdenum and titanium metals have good sulfidation resistance and were recommended for sulphur environments. In chlorine-sulphur atmosphere, sulphur accelerates the corrosion of nickel but high nickel alloys containing chromium and molybdenum were reported to perform reasonably well.

Mackinnon, D.J. "The morphology of zinc deposits electrowon from sulphate and chloride electrolytes"; MRP/MSL 77-43(OP); presented University of Missouri, Rolla, Miss.; March 17, 1977.

Results from an investigation into the effect of chloride ion and organic extractants on the morphology of zinc deposits electrowon from acid sulphate electrolyte are presented. Under the experimental conditions, the effect of chloride ion concentration on the zinc deposit morphology becomes significant only at the 500 ppm level, whereas the tolerance limit of the zinc deposits to organic extractants such as Kellex is extremely low. In some cases the adverse effect of these organic impurities is offset by the presence of chloride ion in the electrolyte.

Results of some preliminary studies on the morphology of zinc deposits electrowon from chloride electrolytes are also presented.

Mackinnon, D.J. and Brannen, J.M. "Zinc deposit structures obtained from high purity synthetic and industrial acid sulphate electrolytes with and without antimony and glue additions"; MRP/MSL 76-337(J); J Appl Electrochem; 7:451-459; 1977.

The addition of either antimony or glue

to the electrolyte produced deposit morphologies and orientations distinctly different from those obtained with addition-free electrolytes. When both antimony and glue were added to the electrolyte, however, the deposit morphologies and crystal orientations were similar to those obtained from addition-free solutions. The various deposit morphologies and orientations were shown to correlate to changes in the zinc deposition over-voltage.

Mackinnon, D.J., Brannen, J.M. and Kerby, R.C. "The effect of lead on zinc deposit structures obtained from high purity synthetic and industrial acid sulphate electrolytes"; MRP/MSL 77-251 (J); J Appl Electrochem; 7:451-459; 1977.

Zinc deposits contaminated with lead had characteristic morphologies and orientations dependent on the amount of lead and on the presence of other impurities such as antimony and glue.

The amount of lead in the zinc deposits was affected by the chemical form of the lead in the electrolyte, by electrolysis conditions such as current density and temperature, and by the nature and concentration of impurities and additives in solution.

A relationship existed between the activation overpotential of zinc deposition and the observed orientations of the zinc deposits. Increased contamination of zinc deposits by lead up to 0.07% gave rise to greater overpotentials and more vertical deposit orientations. For lead concentrations greater than 0.07%, heavily pitted deposits with a basal orientation were obtained.

Makhija, R. and Hitchen, A. "The determination of polythionates and thiosulphate in mining effluents and mill circuit solutions"; MRP/MSL 77-84(J); submitted Talanta; March, 1977.

A method is described for determining total polythionates plus thiosulphate by acidimetric titration. The titration can be carried out either at the methyl orange or at the phenolphthalein end-points, at pH of 4.30 or 8.20, using standard sodium hydroxide solution to estimate the amount of an acid produced on oxidation of the thiosulphate and polythionates to sulphuric acid. The precision and accuracy is good and sample aliquots containing as little as 0.1 mg of the thiosalt can be determined very easily. Results are compared with those obtained by a colorimetric method and are in good agreement.

Malhotra, V.M. "Contract strength requirements — cores versus in-situ evaluation"; MRP/MSL 75-43 (J); J Am Concr Inst Proc; 74:10:529-530; 1977.

This paper discusses problems in evaluating core test data and emphasizes the contradictory nature of available information. Effects of variables such as l/d ratio, embedded reinforcement, type of aggregate, strength level of concrete, direction of drilling, and curing of concrete, are discussed. The unsatisfactory nature of the existing acceptance procedure is underlined and a case is made for its abandonment in favour of a new approach. Concrete delivered to the site

must meet specifications; accelerated strength testing is employed for acceptance testing; and emphasis is placed on in-situ testing of hardened concrete using pull-out, penetration resistance, hardness and pulse velocity methods.

Malhotra, V.M. "Development of CSA standards entitled A23.1-1977 - Concrete materials and methods of construction, A23.2-1977 - Methods of tests for concrete, A23.4-1977 - Precast concrete - materials and construction"; MRP/MSL 77-154(OPJ); presented Can Struct Concr Conf; June 8-9, 1977 and in Proc.

A new edition combining CSA Standards A23.1: Concrete Materials and Methods of Concrete Construction, and A23.2: Methods of Test for Concrete, supersedes previous editions published in 1973, 1967, 1960, 1942 and 1929. A new Standard, A23.4: Precast Concrete - Materials and Construction, has been developed. It is part of the CSA A23 series, Concrete and Reinforced Concrete and will be available in French.

Malhotra, V.M. "Reply to discussions of a paper entitled: Contract strength requirements - cores versus in-situ evaluation"; MRP/MSL 77-211(J); J Am Conc Inst; 74:4; 1977.

Malhotra, V.M., Berry, E.E. and Wheat, T.A.V. (Ed.) "Energy and resource conservation in the cement and concrete industry"; Seminar Proc, sponsored by CANMET and Office of Energy Conservation, EMR; Ottawa; Nov. 8-9, 1976.

Nineteen papers by speakers from the U.S.A. and Canada are presented. Main topics discussed are: energy conservation in the cement industry; aggregate shortages and more efficient use of aggregate production; use of recycled concrete as a new aggregate; use of blended cements, fly ashes, and slags.

Malhotra, V.M. "Superplasticizers in concrete"; MRP/MSL 77-213(J); publication Proc. 1977 Can Struct Concr Conf; sponsored by Struct Div, Can Soc Civ Eng; 1977.

A series of concrete mixes was made at a water cement ratio of 0.42 with a slump of 2 in. (50 mm). Various dosages of three superplasticizers were added after initial mixing. Increases in slumps and their subsequent loss with time were measured. These cylinders and prisms were cast for strength and durability studies. Results confirmed the enormous increase in slumps of superplasticized concretes; however, the increased workability and its loss with time depends on the type and dosage rate of the superplasticizer used. Compressive and flexural strengths were comparable to or in excess of the strength of control specimens and their durability when exposed to repeated cycles of freezing and thawing appeared satisfactory.

Malhotra, V.M., Soles, J.A. and Carrette, G. "Research and development of sulphur-infiltrated

concrete at CANMET, Canada"; MRP/MSL 76-70(OPJ); Proc Madrid Symp on New Uses for Sulphur and Pyrites; 184-201; 1977.

Two infiltration procedures, developed at CANMET, are described. Part I of this paper deals primarily with long-term strength and freeze-thaw durability of sulphur-infiltrated concrete. Part II describes the performance of sulphur-infiltrated concrete in acid and alkaline solutions.

Mathieu, G.I. "Utilization of sodium hypochlorite as a depressant in flotation"; MRP/MSL 77-204(OPJ); presented 1977 Conf Metall, Vancouver; Aug. 21-24, 1977.

Two new applications for sodium hypochlorite as a depressant were recently discovered at CANMET. These were the prevention of arsenopyrite co-flotation during beneficiation of an antimony (stibnite) ore and the depression of cobalt-and arsenic-bearing minerals during the concentration of silver minerals. In both cases, arsenic rejection of more than 85% was achieved.

McCready, R.G.L. "Microbiology in the mineral industry"; MRP/MSL 77-327(J); submitted GEOS; Oct. 1977.

In Canada, one uranium mine is now coming on-stream which will rely 100% on bacterial leaching for uranium production. Thiobacillus ferrooxidans aids in the recovery of metals but can also create problems by producing acid drainage from mine waste. A brief resume of the on-going microbiological research on mine wastes is discussed.

McCready, R.G.L., Rolko, V.H.E. and Wilkins, A.L. "A feasibility study of the use of pentachlorophenol for controlling acid production in pyritic uranium tailings"; MRP/MSL 77-302(TR,J); submitted in Can J Soil Sci; Oct. 1977.

Experiments were conducted to assess the feasibility of using pentachlorophenol for reducing bacterial oxidation in pyritic uranium tailings. Although pentachlorophenol had a long retention time within the tailings material, is chemically and biologically degradable, and is non-herbicidal, its solubility in acidic conditions at pH of 2.0 to 3.75 is too low to achieve bacteriostatic or bactericidal concentrations within the tailings material.

Mirkovick, V.V. and Soles, J.A. "Thermal conductivity of certain rock types and its relevance to the storage of nuclear waste"; MRP/MSL 77-223(OPJ); presented 15th Int Therm Conduct Conf, Aug. 24, 1977 and for publication in Proc.

Nine rocks selected from the surface of three plutons were examined petrographically and their thermal conductivities measured between 100° and 500°C. Thermal conductivities of different rocks varied considerably with composition but they also changed with temperature, but at different rates for different rocks. This indicates that thermal conductivities of rocks and

their changes with temperature are important factors when considering suitability in storing nuclear wastes.

Mirkovick, V.V. "Significance of some thermo-physical properties of rocks to storage of nuclear waste"; MRP/MSL 77-364(OP); presented Lawrence Livermore Lab., Univ of California, Dec. 13, 1977.

Measurements of thermal conductivity, thermal diffusivity and thermal expansion were performed on nine rock specimens between 25 and 500°C and the results evaluated in relation to storage of nuclear waste.

Mirkovich, V.V. "Thermal diffusivity and thermal expansion of some rock types in relation to storage of nuclear waste"; MRP/MSL 77-243(OPJ); presented 15th Int Thermal Conductivity Conf; Aug. 24, 1977, and for publication in *Proc.*

Thermal diffusivities between 25 and 600°C and thermal expansions between 25 and 500°C were determined for nine rocks from three plutons. The thermal diffusivities varied considerably and decreased at different rates with increasing temperature. At 500°C, thermal expansion varied by a factor of 2.5. An empirical relation was used to determine the high-temperature piercing rate as a possible indicator for the spallability of rocks exposed to low-temperature heat loads.

Mirkovich, V.V., Quon, H.H. and Wheat, T.A. "Thermal diffusivity of potassium magnesium titanates having a hollandite structure"; ERP/MSL 77-244(OPJ); presented 15th Int Thermal Conductivity Conf; Aug. 24, 1977, and for publication in *Proc.*

In attempting to develop solid-state ionically conducting materials for potential application in energy storage and conversion systems, the thermal diffusivity was determined for a series of K-ion conducting electrolytes,  $K_xMg_{1-x}Ti_{0.5-x}O_{1.5}$ , where  $1.6 \leq x \leq 1.8$ , between room temperature and 700°C, using a transitory heat-pulse technique. The diffusivity decreased with an increase in  $x$  at any given temperature. Decreasing rate of thermal diffusivity with increasing temperature was found to be dependent on composition within the range of  $x$  from 1.6 to 1.8.

Moloughney, P.E. "An abbreviated fire assay-atomic absorption method for the determination of gold and silver in ores and concentrates"; MRP/MSL 76-119(J); *Talanta*; 24:135-139; 1977.

This paper describes an abbreviated fire assay procedure whereby pyrometallurgical operations are omitted, and solutions obtained from lead assay buttons of approximately 2 g are analyzed for gold and silver by AAS.

Nebesar, B. "Critical review of the high-temperature analytical uses of vanadium(V) oxide"; MRP/MSL 77-98(J); presented, in part, Pittsburgh Conf Anal Chem and App Spectrosc, Cleveland, Ohio, March 4-8, 1974 and submitted *Talanta*, March 31, 1977.

Necessary background is provided for improving methods for determining various elements after their separation from matrices containing vanadium(V) oxide. Evaluation is structured according to the more critical analytical aspects without considering much detail of the analytical methods.

Parsons, H.W. "Dry chlorination of Zn-Pb-Cu-Fe sulphides"; MRP/MSL 77-36(OP); presented AIME Ann Meet - Poster Session; March 6-10, 1977.

A procedure for desulphurizing sulphides by forming either volatile sulphur chlorides or elemental sulphur, with simultaneous metal conversion to chlorides, is described. Oxidation of chlorinated calcine to convert iron chloride to iron oxide - to lower the soluble iron content in a subsequent leach step - is outlined. Difficulties encountered in extracting more than 96% of the metal values and the sulphur are described, and problems to be overcome in evolving a commercial process for treating this ore by a dry chlorination process.

Parsons, H.W. and Ritcey, G.M. "Treatment of complex zinc-lead sulphide ores by chloride metallurgy"; MRP/MSL 77-280(J); *North Min Ann Review*; 63:37:20-21; 1977.

A brief review is presented of techniques involving chloride metallurgy being developed by industry for processing a variety of lower grade or more complex mineral resources. A chlorination process developed at CANMET is also described and illustrated by a conceptual flowsheet.

Petruck, W., Farrell, D.M., Laufer, E.E., Tremblay, R.J. and Manning, P.G. "Nontronite and ferruginous opal from the Peace River iron deposit in Alberta, Canada"; MRP/MSL 76-131(J); *Can Mineral*; 15:14-21; 1977.

Data are provided from a study of Peace River nontronite and ferruginous opal by a variety of techniques including ore microscopy, electron microprobe, X-ray diffraction, infrared spectroscopy, transmission electron microscopy, Mössbauer spectroscopy, and wet-chemical analyses.

Petruck, W., Klymowsky, I.B. and Hayslip, G.O. "Mineralogical characteristics and beneficiation of oolitic iron from the Peace River district, Alberta"; MRP/MSL 76-246(J); *CIM Bull*; 70:786:122-131; 1977.

This paper deals with mineralogical characteristics that affect the behaviour of the material in ore dressing, and the response of the material to gravity separation, magnetic separation and flotation treatment. The flotation investigation involved testing reverse flotation, direct flotation, and selective flocculation and desliming to develop the best flowsheet. A mineralogy summary is included.

Petruck, W. and Hughson, M.R. "Image analysis evaluation of the effect of grinding media on selective flotation of a zinc-copper ore from Mat-

tagami Lake Mines Limited"; MRP/MSL 76-98(J); Proc 9th Can Miner Proc; 58-76; and CIM Bull; 70:782:128-135; 1977.

Image analysis studies to determine effect of grinding media on selective flotation of a zinc-copper ore are described. Data suggest when ore is ground with steel balls, chalcopryrite tends to be depressed in the copper flotation cells. Therefore, in the absence of steel, more chalcopryrite tends to float and be recovered.

Petruk, W. and Klymowsky, I.B. "The behaviour of minerals in the Heath Steele grinding circuit"; MRP/MSL 78-80(OP); Abstract presented Ann Meet Metall, Montreal; Aug. 27-31, 1978.

Petruk, W. "The lower size limit for recovering free sphalerite grains by flotation"; MRP/MSL 77-255(OP); presented 16th Ann Conf Metall; Aug. 23, 1977.

Image analysis was performed on flotation feeds, zinc concentrates, and tails to determine whether very small free sphalerite grains are recovered by flotation. The results show that the proportion of free sphalerite grains recovered in the zinc concentrates was about 99% of grains larger than 6  $\mu\text{m}$  in diameter and 50% of those smaller than 6  $\mu\text{m}$ . Recovery of grains smaller than 6  $\mu\text{m}$  decreased with decreasing grain size. The proportion ground into free grains smaller than 6  $\mu\text{m}$  when a base metal ore was ground to 80% minus 270 mesh was 9%; to 80% minus 400 mesh it was 12%; and to 80% minus 18  $\mu\text{m}$  44%. Consequently, the amount of sphalerite lost due to sliming was less than 6% when the ore was ground coarser than 80% minus 400 mesh, but was 20 to 25% when the ore was ground to 80% minus 18  $\mu\text{m}$ .

Quon, D.H.H. and Wheat, T.A. "Preparation and characterization of the K-ion conductor  $\text{K}_x\text{Mg}_{x/2}\text{Ti}_{8-x/2}\text{O}_{16}$ "; ERP/MSL 78-50(OP); presented Can Ceram Soc, Toronto; Feb. 27, 1978, and Am Ceram Soc Detroit; May 10, 1978.

A series of K-ion conductors,  $\text{K}_x\text{Mg}_{x/2}\text{Ti}_{8-x/2}\text{O}_{16}$ , where  $1.4 \leq x \leq 2.0$ , has been determined and is presented as part of a program to develop solid-state ionically conducting materials for potential application in energy storage and conversion systems. Experimental procedure, results and discussion are presented.

Ritcey, G.M. "Treatment of radioactive ores at CANMET"; ERP/MSL 77-139(OP); presented Can Uran Prod Metall Comm, Ottawa; May 19, 1977.

A brief outline is given for an integrated program for developing improved extraction processes for uranium resource conservation, pollution reduction, and studying new ore treatment processes.

Ritcey, G.M. "CANMET research pertaining to  $\text{Ra}^{226}$ "; ERP/MSL 77-287(OP); Contribution Workshop on  $\text{Ra}^{226}$  Control, Ottawa; Oct. 17, 1977.

A summary is given of each of the fol-

lowing on-going research projects: radium sampling in mill; continuous ion exchange processing; flotation of tailings; microbial degradation of  $\text{Ba/RaSO}_4$  sludges; interaction of solvent extraction organics and bacteria on tailings weathering. Development of new technology is described for nitric acid leaching, the hydrochloric acid process, and the chlorination process.

Ritcey, G.M. and Lucas, B.H. "Recovery of chromium and vanadium from alkaline solutions produced by an alkaline roast-leach of titaniferous magnetite"; MRP/MSL 77-153(OP); presented Int Solv Extract Conf, Toronto; Sept. 1977.

An integrated process is described for treating low-grade iron ore after beneficiation consisting of a combination of magnetic concentrations followed by alkaline roasting of the calcine. Estimated capital and operating costs are shown.

Saiddington, J.C. "Effect of plating interruptions on surface appearance of electrodeposited chromium"; MRP/MSL 77-97(J); presented joint meeting, Electrochem Soc Detroit Section and Electroplaters Soc, Detroit Branch, Detroit, Jan. 12, 1976 and for publication in Plating.

Employing various interruptions during deposition of Cr on bare or nickel plated steel and making detailed microscopic examination of the surface of each deposit showed that less in lustrous appearance is due to numerous nucleation sites after each interruption. These sites serve subsequently as centres for the growth of outward dome-like projections which act as miniature convex mirrors dispersing the impinging light, thus decreasing overall surface reflectivity. Possible involvement of the nucleation processes in the stress relieving mechanism leading to the elimination of crack formation is discussed.

Senesi, N., Griffith, S.M., Schnitzer, M. and Townsend, M.G. "Binding of  $\text{Fe}^{3+}$  by humic materials"; MRP/MSL 76-286(J); Geochim Cosmochim Acta; 41:969-976; 1977.

Data are provided on oxidation states and site symmetries of Fe bound by humic and fulvic acids. Electron Spin Resonance and Mössbauer spectroscopy were combined with chemical treatments such as acid hydrolysis, reduction with hydrazine and complexation with ammonium thiocyanate to obtain these data.

Soles, J.A., Carette, G.G. and Malhotra, V.M. "The stability of sulphur-infiltrated concrete in various environments"; MRP/MSL 77-49(OPJ); presented Am Chem Soc Symp "Utilization of Sulphur", New Orleans, March 23, 1977 and for publication in Proc.

Experiments with sulphur-infiltrated concrete have shown it to be more durable in most environments than untreated normal portland cement concretes. Characterization of infiltration and leaching products are described and the reactions involved are discussed.



Steger, H.F. and Desjardins, L.E. "Oxidation of sulphide minerals. IV. Pyrite, chalcopyrite and pyrrhotite"; MRP/MSL 77-56(J); publication in Chem Geol.

This paper describes results of applying analytical methods to ascertain the nature of the oxidation of pyrite, pyrrhotite and chalcopyrite at 52°C and 68% relative humidity, RH.

Steger, H.F. and Desjardins, L.E. "Air-oxidation of sulphide minerals"; MRP/MSL 77-120(OP); presented CIC-ACS Conf, Montreal; May 31, 1977.

An investigation was made to better understand air-oxidation of the more common sulphide minerals and to permit an extrapolation of observed behavior of individual minerals or of simple mixtures thereof to that more complex certified ores and concentrates. The major difficulty in oxidation at  $T < 100^\circ\text{C}$  was identification and determination of small amounts of products formed during reasonable time periods. Analytical methods for determining these products are described.

Steger, H.F., Faye, G.H., Bowman, W.S. and Sutarno R. "Some special problems in the certification of reference materials"; MRP/MSL 78-63(OP); presented Geoanalysis 78, May 17, 1978

It is shown how a critically assessed reference method was used to certify an iron ore for sodium and potassium when consensus values could not be obtained in a "free-choice of method" interlaboratory program. Oxidation of two sulphide-bearing reference materials and their recent recertification is described.

Steger, H.F., Mark, E. and Desjardins, L.E. "The drying of sulphide-bearing materials in a microwave oven: a caveat"; MRP/MSL 77-222(J); submitted Talanta; Aug. 1977.

The drying of sulphide-bearing materials in a microwave oven should be undertaken with caution. Several sulphide minerals and sulphide-bearing materials have shown a susceptibility to oxidation during microwave drying which could affect the results of subsequent work on these materials. Some typical results are presented.

Subrahmanyam, D.V. and Hoey, G.R. "Potassium oxalate inhibits corrosion of mild steel by ferric ion"; MRP/MSL 75-78(J); Corrosion; 33:8:295-300; 1977.

Studies are summarized on influence of potassium oxalate on the corrosion and electrochemical behaviour of mild steel in pH 2.5 sulphuric acid solutions with and without  $\text{Fe}^{3+}$  ions. Possible application of potassium oxalate in the mineral industry are suggested.

Townsend, M.G. "Mössbauer effect data index, covering the 1975 literature" (J.G. and V.E. Stevens, Ed.); MRP/MSL 77-267(J); Phys Can; 33:7: 115; 1977.

A review is presented on the above data index. A rapidly growing number of researchers in many different disciplines are using Mössbauer spectroscopy as a research tool and should certainly have access to this excellent data index.

Townsend, M.G. "Crystal field effects in metals and alloys" (A. Furrer, Ed.); MRP/MSL 77-306(J); Phys Can; 33:7:116; 1977.

A review is presented of a series of papers, 58 presented at the 2nd International Conference on Crystal-Field Effects in Metals and Alloys, Zurich, Switzerland, Sept., 1976. For those interested in the elucidation of experimental and theoretical aspects of spin-waves and excitons, soft modes and critical effects, magnetic properties, physical properties influenced by crystal field effects and actinides and valency, the book provides a very useful source of information.

Townsend, M.G. and Muir, W.B. "A magnetic and Mössbauer study of magnetic ordering and vacancy clustering in  $\text{Cu}_5\text{FeS}_4$ "; MRP/MSL 77-51(OP); presented Can Assoc Phys Ann Meet, Saskatoon; June 1977.

Magnetic susceptibilities and Mössbauer spectra recorded between  $4^\circ$  and  $300^\circ\text{K}$  show that the low temperature form of  $\text{Cu}_5\text{FeS}_4$ , bornite, orders magnetically at  $76 \pm 2^\circ\text{K}$ . At  $8^\circ\text{K}$ , a second magnetic phase transition occurs.

Townsend, M.G., Gosselin, J.R., Horwood, J.L., Tremblay, R.J. and Ripley, L.G. "Violarite, a metallic natural spinel"; MRP/MSL 76-294(J); Phys Stat Sol; 40:K25-K29; 1977.

An examination was made of synthetic and natural violarite by magnetic susceptibility, thermoelectric power and Mössbauer spectroscopy. Results are described on a synthetic  $\text{Fe}_{1.22}\text{Ni}_{1.81}\text{S}_{3.97}$  and a natural  $\text{Ni}_{1.63}\text{Fe}_{1.01}\text{Co}_{0.33}\text{S}_{4.02}$ . Violarite is shown to be metallic and Pauli-paramagnetic with an inverted spinel structure.

Tremblay, R.J., Mathieu, C., Pepin, R. and Townsend, M.G. "Measurement of radon progeny concentrations in air by  $\alpha$ -particle spectrometric counting during and after air sampling intervals"; MRP/MSL 77-241(J); publication in Health Phys. 1977.

A technique is presented for measuring air concentrations of the short-lived progeny of radon-222 using  $\alpha$ -particle spectrometry. The procedure calculates concentrations of RaA, RaB and RaC from one integral  $\alpha$ -count of RaA and two integral  $\alpha$ -counts of RaC', with counting intervals during and/or after sample collection on a filter with an air-sampling device. A computer program is presented which calculates the concentrations of RaA, RaB and RaC in air and the accuracies in these calculated concentrations.

Wheat, T.A. "Techniques for producing reactive and homogeneous ceramic powders"; MRP/MSL 77-34 (OPJ); presented Ann Conv Can Ceram Soc; Feb. 21, 1977 and publication in Can Ceram Soc.

Methods for producing necessary reactive and homogeneous raw materials are discussed and advantages and disadvantages of each are outlined.

Wheat, T.A. "Ionically conducting ceramics and their applications"; ERP/MSL 78-47(OPJ); presented Elect and Basic Sci Div., Can Ceram Soc; Feb. 1978 and for publication in J Can Ceram Soc.

Groups of ionically conducting ceramics are surveyed from the point of view of their electrical and structural characteristics and present and potential applications are given for this increasingly important class of materials.

Winer, A.A. "Sources of Canadian non-bauxite alumina"; MRP/MSL 77-130(OPJ); presented Seminar on Coal Refuse Disposal and Utilization, May 18, 1977, Lexington, Kentucky and for publication in Proc.

Identification of potential indigenous alumina-bearing materials has been initiated, as well as experimental laboratory investigations of selected non-bauxite materials — anorthosite, clays and shales, coal washing rejects, underclays, fly ash, and nepheline syenite. Anorthosite appears to have greatest potential because it is present in large quantity and is of reasonable quality (26-28%  $Al_2O_3$ ). Occurrences of materials and typical analyses are noted. Current research at CANMET and proposed future work are briefly described.

Winer, A. and Buchanan, R.M. "Thermal insulation from Canadian mineral materials"; MRP/MSL 77-289 (J); North Min; 63:37:A20; 1977.

CANMET has successfully made insulation from slags and asbestos tailings on an experimental scale. Slags and argillaceous dolomite are both obtainable and are being used in Canada for mineral wool production. Information is given on other minerals and rocks with potential for min-

eral wool production and statistical data are provided.

Winer, A. and Malhotra, V.M. "Fibre reinforcement of cement and sulphur concretes"; MRP/MSL 75-203(J); 1st Int Symp Fibres in Concr Proc; 2:577-581; 1977.

This two-part investigation describes a study into the use of asbestos fibres in portland cement and sulphur concretes, specifically to determine the effect of fibre incorporation on the workability and mechanical properties of these concretes.

Winer, A.A. and Quon, D.H.H. "Non-bauxite sources of alumina in Canada: extraction of alumina from anorthosite by alkali sintering"; MRP/MSL 77-171 (OPJ); presented CMS-ICSOBA Conf, Kingston, Jamaica, Aug. 12-20, 1977, and for publication in Proc, Tech Session.

Various processes are being investigated at CANMET including the lime-soda sinter and lime-sinter processes using anorthosite. Under laboratory conditions, up to 98% of the available alumina was extracted from a sample of anorthosite. Details of the lime-soda sinter process are discussed in terms of reactant compositions, sintering temperature and time for maximum alumina yield. Gelation was not a serious problem in the lime-soda sinter process, providing excessive  $Na_2O$  loss is avoided during sintering.

Zimmerman, J.B. and Lalonde, C.R. "The determination of aluminum, silicon, calcium, iron and titanium in non-bauxite sources of alumina by X-ray fluorescence analysis"; MRP/MSL 77-63(J); Can J Spectrosc; 22:99-102; 1977.

The method of X.R.F. analysis utilising Tertian's Double Dilution Technique has been applied to a variety of materials and has proved acceptable for the determination of aluminum, silicon, iron, titanium and calcium. It has also proved advantageous in supplying additional information concerning non-bauxite sources of aluminum.

## PHYSICAL METALLURGY RESEARCH LABORATORIES

Bell, D.R. and Boyd, J.D. "Design of steels for Arctic line pipe"; ERP/PMRL 77-9(J); Design Eng; 23:6:18-20; 1977.

Development of a new class of steel with a unique combination of weldability, improved strength and substantially improved toughness at relatively low cost is illustrated by comparing specification requirements for Arctic and conventional pipelines. Changes in microstructural parameters required to achieve these improvements are outlined and changes in composition and processing highlighted. Present capability of Canadian producers to meet quantity and quality requirements of the proposed northern pipelines is noted.

Bieffer, G.J. "Exploratory corrosion testing in the Canadian Arctic"; MRP/PMRL 77-4(OP); presented CIM Conf Metall; Vancouver; Aug. 21-25, 1977; NACE Eastern Regional Conf; Montreal; Sept. 27-29, 1977.

To determine both the feasibility and usefulness of corrosion testing in the Canadian Arctic, exploratory measurements were made on carbon and alloy steels in sea water in inlets of the Arctic Islands and in the atmosphere at Tuktoyaktuk, N.W.T. Results are compared with data obtained from southern Canada.

Boyd, J.D. "Microstructure and toughness in high-strength linepipe steels"; ERP/PMRL 77-2(OP); presented Symp on Toughness Characterization and Specifications for HSLA and Structural Steels, Atlanta, GA; March 8-10, 1977 and TMS-AIME, New York; 1978 (in print).

The low temperature impact toughness (Charpy) of a number of laboratory heats of HSLA linepipe steels are correlated with their microstructures. Four microstructural parameters and their effects on toughness are examined: i) ferrite grain diameter or bainite packet diameter, ii) volume fraction of ferrite boundary carbide, iii) dislocation density, and iv) volume fraction of intragranular precipitates.

Buhr, R.K. "Federally funded ferrous foundry research in Canada"; MRP/PMRL 77-8(OP); presented plant operators, Canadian-produced ferrous castings; Cleveland, Ohio; Oct. 28, 1977.

A brief introduction is given to CANMET's Physical Metallurgy Research Laboratories (PMRL) and some of PMRL's foundry research activities are described.

Edwards, J.O. "The potential of recycling in zinc conservation"; MRP/PMRL 77-6(OP); presented CIM Conf Metall; Vancouver; Aug. 21-25, 1977.

Available statistics on the uses and

Canadian consumption of zinc are given. Individual uses are outlined: galvanizing, alloys, die casting, wrought products, oxides, chemicals, zinc dust, etc. Important considerations to recycling are dealt with.

Edwards, J.O. and Dixon, C.F. "Bronze plaque casting by the V process"; MRP/PMRL 77-1(J); Foundry; 65:28-36; 1977.

Excellent results from experiments on the "V" process — patented vacuum moulding invented in Japan — prompted the Physical Metallurgy Research Laboratories of CANMET to use this process for casting a commemorative bronze plaque for naming of the Sir William Logan Building, new headquarters of the Department of Energy, Mines and Resources. A step-by-step description of the plaque production is given.

Laufer, E.E. "Improved dark field technique for TEM examination and identification of small crystalline particles"; MRP/PMRL 78-2(OP); presented 9th Int Cong Electron Microsc; Feb. 1978.

A simple technique is described for determining "d" spacings for powder samples using the beam-tilt device of the Philips EM300 electron microscope.

Packwood, R.H., Laufer, E.E. and Roberts, W.N. "Graphite support grids for X-ray analysis in the electron microscope"; MRP/PMRL 77-7(J); Proc 8th Int Conf X-ray Optics and Micro; paper 115; Boston; Aug. 18-24, 1977.

Methods are described for obtaining clean characteristic X-ray spectra from an energy dispersive X-ray analysis system, installed in a transmission electron microscope. Methods are also described for making graphite specimen support grids to replace the conventional copper grid which is a source of spurious  $\text{Cu-K}_{\alpha,\beta}$  radiation.

Skelly, H.M. and McGoe, J.T. "A composite specimen made from iron and aluminum-silicon powders"; MRP/PMRL 77-17(J); Int J Powder Metall and Powder Tech; 14:2; 1978.

The production and crushing test of a composite of iron and an aluminum-35% Si alloy are described. The crushing test showed that the alloy had good adherence to the iron ring.

Stewart, M.J. "The use of hot rolling simulation and pilot-scale rolling to determine mill operating parameters for HSLA steels"; ERP/PMRL 77-5(OP); presented 16th Ann Conf Metall, Vancouver; Aug. 21-25, 1977.

This paper shows the type of information that is available from using a cam plastometer to

simulate hot rolling and also shows the usefulness of a pilot-scale mill in assessing the rolling behaviour of different steels.

Thomson, R. "A micro-mill for strand-casting steel"; MRP/PMRL 77-7(OP); presented CIM Conf Metall, Vancouver; Aug. 21-25, 1977.

Factors which originally supported the mini-mill concept for the continuous casting of steel may now be used to support a new technology aimed again at viable low volume production. This paper discusses the horizontal or vertical closed-head casting of small sections, as widely practised by non-ferrous and cast iron producers of semi-finished products, and details problems and advantages. The technical feasibility of low volume, small section casting — a micro-mill — is illustrated by brief reference to the production and properties of continuously cast high-speed tool steel.

Tobe, Y. and Tyson, W.R. "Effect of hydrogen on yield of iron"; MRP/PMRL 77-12(J); Scripta Met; 11:849; 1977.

In recent years accumulated evidence has shown that hydrogen can be bound to dislocations, transported by them, and influence their mobility. By analogy with other interstitial solutes in iron, hydrogen should cause the classic formation of atmospheres, yield points, and flow stress elevation. Experimental procedure and results are described.

Tyson, W.R. "Surface analysis in physical metallurgy: Progress in temper embrittlement control"; ERP/PMRL 77-22(J); submitted CIM Bull; Dec. 1977.

This paper traces the progress in understanding temper embrittlement and indicates other areas where control of interfacial segregation and its effects can be important in metallurgical applications.

Vosikovsky, O. "Corrosion fatigue subcritical crack extension in a crude-oil pipeline"; ERP/PMRL 77-3(OP); presented Pacific Northwest Metals and Miner Conf, Seattle, Washington; May 5-6, 1977.

Corrosion fatigue constitutes one of the phenomena under the general heading environment-assisted fracture, or environmental cracking.

Fatigue crack growth rates are shown for X-65 line-pipe steel in 3.5% NaCl solution at free-corrosion and cathodic potentials (chosen to represent outside environment in a pipeline) and in crude oil with two contents of  $H_2S$ . Data for sour crude oil are used to predict the fatigue lives of a pipeline for different depths of initial defect.

White, D.W.G. and Boyd, J.D. "HSLA steels — a new family of steels for the north"; ERP/PMRL 77-21(J); Eng J; 61:1:32-34; 1978.

A comparison is made of improved high-strength low-alloy (HSLA) steels with conventional carbon-manganese structural steels. Characteristic properties, their metallurgical effects, how these properties are achieved, and new equipment needed are outlined.



## ENERGY RESEARCH LABORATORIES

Friedrich, F.D., Lutes, I.G. and Wheeler, C.M. "Fluidized-bed combustors for coal drying"; ERP/ERL 77-63(OP); presented 27th Can Chem Eng Conf, Calgary; Oct. 23-26, 1977.

Pilot-scale tests were conducted in a 2-ft (0.6 - m) diam fluidized-bed combustor using both a high-ash Alberta coal and simulated washery rejects of the same coal containing up to 70% ash. Both coals burned successfully at temperatures suitable for commercial coal-drying. It is concluded that existing fluidized-bed combustion technology, having no in-bed heat transfer surfaces and as presently used commercially for disposal of wood waste and sewage sludge, could be used to fire a coal dryer, using coal-washery rejects as fuel.

Frost, D.C., Leeder, W.R., Tapping, R.L. and Wallbank, B. "An XPS study of the oxidation of pyrite and pyrites in coal"; Fuel (London) 56:277-280; 1977.

X-ray photoelectron spectroscopy (XPS) was used to study mineral, synthetic and coal-associated pyrites to determine if XPS could detect, monitor and clarify pyrite surface-oxidative changes that influence surface-dependent coal-cleaning methods and could provide a means of directly analyzing coal sulphur. Conditions of study are described and results indicate that the XPS S2p pyrite peaks at  $\approx 169$  eV and the surface-oxidation-product peak at  $\approx 163$  eV and that these could be detected and followed with XPS, although no conclusions could be made about the oxidation mechanism.

Furimsky, E. "Chemical origin of coke deposited on catalyst surface"; ERP/ERL 77-99(J); submitted J Ind Eng Chem; Nov. 1977.

A marked difference has been observed in the chemical composition between coke deposits formed during catalytic hydrotreatment of bitumen and heavy gas oil. In the latter, more nitrogen and oxygen accumulate in the deposit, attributed to different coke precursors, i.e., to heterocyclic compounds in the gas oil and to heavy asphaltene species in the bitumen, respectively. Also, metals, when present, concentrate in the deposits too. The vanadium/nickel ppm ratios in the deposits are almost 9, while ppm ratios in the bitumen feed is only about 3, suggesting that when vanadium is present, it will have a much more detrimental effect on catalyst activity than will nickel.

George, A.E., Banerjee, R.C., Smiley, G.T. and Sawatzky, H. "Simulated geothermal maturation of Athabasca bitumen"; Bull Can Pet Geol; 25:5:1085-1096; Sept. 1977.

Athabasca bitumen was subjected to thermal treatment of increasing severity under reducing conditions. The generation as well as the change in relative distributions of different components were followed and the resulting products were compared with other Cretaceous oils in the Western Canada Tar Belt having varying degrees of maturity. This study indicates that Athabasca bitumen is an immature material.

Gransden, J.F., Reeve, D.A., Walsh, J.H. and Rehder, J.E. "Ironmaking from Peace River iron ore by smelting ore-char briquets in a cupola"; MRP/ERL 77-86(J); submitted CIM Bull; Oct. 1977.

A smelting process has been developed to treat the iron deposits of the Peace River district of Alberta which have previously proved difficult to upgrade. The unbeneficiated ore is agglomerated with char and smelted in a cupola. The char reduces the iron oxides to iron, and process heat is provided by burning foundry coke. About 75% of the iron in the agglomerates is recovered in the pig iron. The process uses an acid slag so that the hot metal requires desulphurization before steelmaking.

Hamza, H.A. "A systematic approach for flocculant selection and evaluation"; ERP/ERL 78-7(OP); presented 10th Can Miner Proc Ann Meet, Ottawa; Jan. 24-26, 1978.

Various factors affecting flocculation are discussed and their significance in the process is indicated. A systematic procedure of flocculant selection for a given application is proposed which includes characterization of the solid-liquid system and prescreening of commercially available flocculants on the basis of the system determined criteria. A method of economic evaluation based on performance parameters is introduced.

Hayden, A.C.S. "Utilization of methanol in stationary source combustion"; ERP/ERL 77-115(J); prepared for Ont Advis Group Syn Liq Fuels; Nov. 1977.

The paper deals with the potential use of methanol as a fuel substitute in stationary source combustion. Methanol should only be considered for replacing premium fuels, defined as No. 2 or lighter oil or natural gas. Fuel properties of methanol are presented in the form of combustion charts, illustrating the high heat loss potential with methanol because of hydrogen in the fuel.

Hayden, A.C.S., Braaten, R. and Brown, T.D. "Oil conservation in home heating"; ERP/ERL 76-55(OPJ);

Trans Am Soc Mech Eng; Ser A, 99:3:413-419; 1977.  
Abstract in Catalogue of CANMET Publications, 1976/77, CANMET Report 78-6, p 96.

Hayden, A.C.S., Braaten, R.W. and Brown, T.D. "Emissions and energy conservation in residential oil heating"; ERP/ERL 77-73(J); submitted J Air Poll Cont Assoc; July 1977.

This paper describes part of a continuing research program conducted by CANMET devoted to fuel conservation in oil-fired residential heating equipment. Records are presented of daily fuel consumption in several test homes over three consecutive winters. Early results established the relative merits of fuel conservation strategies.

Khulbe, K.C., Mann, R.S. and Ternan, M. "Electron spin resonance studies of the surface chemistry of molybdenum-alumina catalysts"; Can J Chem; 56:13: 1769-1772; 1978.

This paper describes the effect of variation in the concentration of electron accepting centres (Lewis acid sites) with the variation of molybdenum concentration and an attempt is made to correlate these centres with the denitrogenation and desulphurization activity. The effect of heating in vacuo at 320°C and the reversible behaviour of oxygen on the heated and evacuated catalyst is also described.

Kriz, J.F., Belinko, K. and Nandi, B.N. "The effect of tin catalysts on hydrotreating of Athabasca oil sand bitumen and on coal hydrogenolysis"; ERP/ERL 78-27(OP); presented Am Chem Meet, Miami, Florida; Sept. 1978.

Information is provided on an investigation on the suitability of different catalyst systems for hydrocracking heavy oils involving the use of tin compounds with bitumen and heavy oil feeds. A series of tin-containing catalysts was tested for bitumen and coal upgrading. Emphasis was placed on studying the changes occurring within the catalysts during various processes.

Kriz, J.F., Ternan, M. and Packwood, R.H. "Surface layering within the grains of an alumina support and its effect on hydrotreating catalysts"; ERP/ERL 77-5(J); submitted Ind Eng Chem; Prod Res Dev; Sept. 1977.

This paper presents evidence that surface layering can occur during the preparation of hydrotreating catalysts. Variables investigated included type of alumina monohydrate, particle size of alumina monohydrate and the procedure used to impregnate the catalytic ingredients into the support.

Leeder, W.R. and Price, J.T. "The effect of partial agglomeration of coke-oven charges upon coke quality"; ERP/ERL 77-67(OP); presented Int Briq Assoc Conf, Montreal; Aug. 22-25, 1977.

This report surveys investigations into partial agglomeration of coke-oven charges. Effects of briquet preparation and oven bulk density are discussed.

Evidence indicates that partial agglomeration can improve coke quality and extend the coking coal range to include less expensive coals.

Nandi, B.N., Brown, T.D. and Lee, G.K. "Inert coal macerals in combustion"; Fuel (London); 56: 125-130; 1977.

This paper describes one aspect of a program to establish suitability of two unknown coals for use in large utility boilers in Eastern Canada — a Western Canadian bituminous and a washed Western Canadian subbituminous coal. Their proximate and ultimate analyses are given together with analysis of a Pennsylvania bituminous coal which was the reference fuel for comparative evaluations.

Nandi, B.N., Ghosh, A. and Ciavaglia, L.A. "Anomalous microhardness impressions of some weathered coals"; ERP/ERL 77-91(J); submitted to Fuel; Oct. 1977.

This paper investigates ability of the microhardness impression test to detect oxidation of coals of different geological age and rank and also to determine the cause of failure of the vitrinite of certain coals to become elastic after oxidation. One French coal from the upper Stephanian age and two Indian coals from the Gondwana age were tested.

Pruden, B.B. and Denis, J.M. "Hydrogenate bitumen says CANMET"; Can Chem Proc; 61:6:37-38; 1977.

CANMET has developed a thermal hydrocracking process which concentrates all metals and mineral matter in a small pitch fraction and produces a high yield of low viscosity distillate for subsequent catalytic hydrotreating. This paper lists the advantages of this process compared with current and future industrial coking processes. A schematic diagram is provided of a one-barrel-per day pilot plant which simulates a commercial process.

Reeve, D.A. and Price, J.T. "Evaluation of iron oxide materials at high temperatures"; MRP/ERL 77-21(J); North Min; C6-C8; Apr. 14, 1977.

Test procedures to evaluate iron oxide materials under simulated blast furnace conditions, some of which may in the future be written into contract specifications, are being developed within the forum of the International Organization for Standardization as international standards. Test facilities have been established at CANMET, Ottawa, under the auspices of the Canadian Advisory Committee on ISO Technical Committee 102 which is partially funding the research work through grants from industry. Tests under consideration and their relevance to blast furnace operation are summarized.

Sawatzky, H., Beshai, J.E., George, A.E. and Smiley, G.T. "Chemical changes in nitrogenous ma-

terials during hydrocracking of Athabasca bitumen"; ERP/ERL 77-88(OP); presented Am Chem Soc Nat Meet, Anaheim, California, March 1978 and published Preprints; 23:1:21-29; 1978.

Nitrogenous materials in synthetic crude oils are important because they deactivate the catalysts in refining processes, e.g., desulphurization, hydrogenation, aromatization, etc. This report describes an investigation of these nitrogenous compounds in synthetic crude oils obtained from Athabasca bitumen at various severities of non-catalytic thermal hydrocracking.

Sawatzky, H., George, A.E. and Smiley, G.T. "Chemical investigations of the hydrocracked products of Athabasca bitumen"; ERP/ERL 77-35(OP); presented Canada-Venezuela Oil Sands Symp 77 Edmonton; May 27-June 4, 1977.

Hydrocracking processes for upgrading Athabasca bitumen reduce or eliminate waste coke production and produce high quality synthetic crude oils. The work described is a continuation of previous studies and results for the catalytically hydrocracked products are compared with those from non-catalytic processes.

Sekhar, M.V.C., Schuit, G.C.A. and Ternan, M. "Catalytic gasification of pitch derived from hydrocracked Athabasca bitumen"; ERP/ERL 78-2(OP); presented Chem Inst Can; June 1, 1978.

Abstract only presented.

Sekhar, M.V.C. and Ternan, M. "Thermogravimetric studies on pyrolysis of pitch derived from hydrocracked Athabasca bitumen"; ERP/ERL 77-94(J); presented Am Chem Soc, Pet Div, Anaheim, California and in Preprints; 23:1:208-217; 1978.

When molecular weight reduction occurs from Athabasca bitumen via the hydrocracking process, it produces 5 to 10% pitch boiling above 525°C which contains high concentrations of sulphur, nickel, vanadium, and iron. Therefore, pyrolysis of pitch was investigated prior to studies on gasification to gain appreciation for pitch pyrolysis and gasification reactions which may lead to a better method of pitch utilization. Data are presented in this paper which indicate the importance of pyrolytic reactions, the bulk of which occur below 500°C.

Whaley, H., Braaten, R.W. and Savignac, D.G. "Energy conservation and emissions from two residential furnaces using an emulsified water-in-oil fuel"; ERP/ERL 78-23(OP); presented 71st Ann Meet Air Poll Control Assoc, Houston, Texas; June 25-29, 1978.

A test program is described which was conducted by CANMET to evaluate water-in-oil emulsions as an energy conservation strategy in residential heating. Two typical furnaces — a warmair furnace and a hot-water boiler — were selected for testing using a chemically stabilized, mechanically produced emulsion. They were fired with No. 2 fuel oil and with emulsions with up to 60% by volume of water. Other conservation strategies

such as nozzle size reduction and burner head modification were included in the test program for comparative purposes.

Whaley, H. and Lee, G.K. "Plume dispersion in a mountainous river valley during spring"; ERP/ERL 75-107(OP); J Air Poll Cont Assoc; 27:1001-1005; 1977.

Abstract in 1976 Catalogue of CANMET Publications, CANMET Report 76-31, p 83.

Whaley, H. and Lee, G.K. "The behaviour of buoyant plumes from an oil-sands refinery complex"; ERP/ERL 77-33(OP); presented Canada-Venezuela Oil Sands Symp 77, Edmonton; May 27-June 4, 1977 and in Proc; 732-742; 1977.

This report describes plume dispersion studies at an oil-sands refinery in northern Alberta during fall and winter. Derived dispersion parameters are compared with those currently used in environmental impact studies. Results show that present empirical formulae for predicting plume behaviour and impingement patterns cannot be applied with confidence in this region.

Whaley, H., Lee, G.K. and Gainer, J.G. "High volume flaring of sour gas under limited mixing conditions"; ERP/ERL 77-107(OP); presented Alberta Sulphur Gas Research Workshop III, Univ of Alberta, Edmonton; Nov. 17-18, 1977 and in Proc; pp 94-108; 1977.

A review is presented of the first known aerial studies of a sour gas plant under abnormal plant flaring conditions and the results of dispersion studies conducted under these unique plant emission rates. Data indicate that a limited condition can be predicted for both the plume axis elevations and the standard deviations of plume spread during limited mixing conditions.

Whalley, B.J.P. "Coal beneficiation"; ERP/ERL 77-39(OP); presented National Advisory Committee on Mining and Metallurgy, Energy Supply Sub-committee on the Energy Research Program, Ottawa; Apr. 15, 1977.

Coal beneficiation, although a processing activity, has a direct bearing on coal supply and reserve assessment. The Western Research Laboratories of CANMET was established 21 years ago and an outline is presented of its history, achievements, process developments, and future research plans.

Whalley, B.J.P. and Lau, I. "Instrumental anticipation of defluidization of heated beds of caking coals"; ERP/ERL 77-90(OP); presented 27th Can Chem Eng Conf, Calgary; Oct. 23-27, 1977.

This paper describes investigations for testing the capability of DT probes to characterize and control the behaviour of heated fluidized beds. In particular it deals with results additional to preliminary observations made on the ability of DT probes to anticipate defluidization of heated beds of caking coals.

## MINING RESEARCH LABORATORIES

Bossert, J.A. "Certification laboratories for coal mining equipment"; MRP/MRL 77-111(J); North Min Ann Rev; Nov. 24, 1977.

From visits made to certification laboratories for coal mines in England, France, Germany, U.S.A., the Soviet Union and Japan the author gives his impressions of facilities in other countries as they compare with Canada's Certification Laboratory at CANMET.

Chakravorty, R.N. and Feng, K.K. "Studies on the early detection of spontaneous combustion in a hydraulic coal mine"; ERP/MRL 77-42(OP); presented 79th Ann Gen Meet, CIM, Apr. 17-21, 1977, CIM Bull; 71:789:83-91; 1978.

Work is described for developing a suitable system for early detection of heating in hydraulic coal mines. A recently installed four-point carbon monoxide monitoring system is discussed. Field tests indicate that infrared technology will prove a powerful tool, particularly for locating hidden oxidation or fire in cracks, fissures, underground workings and coal outcrop areas.

Chakravorty, R.N. and Fisekci, M.Y. "Control and measurement of methane gas in coal mines"; ERP/MRL 77-47(TR); Ecol; 3; 1977.

An outline is given of the various control methods and measuring devices for reducing and monitoring methane concentration in mine air. A brief description of research activities underway for the control and measurement of methane gas by the Mining Research Laboratories of CANMET is presented.

Chakravorty, R.N. and Woolf, R.L. "Environmental monitoring for safety in underground coal mining"; ERP/MRL 78-20(OP); presented 80th Ann Gen Meet, CIM, Vancouver; Apr. 23-27, 1978.

This paper reviews the state-of-the-art in monitoring technology with particular reference to hazardous gas detection in underground coal mines. Preliminary results from ongoing studies, of continuous monitoring of methane and carbon monoxide in mine air in some of the operations in Western Canada, are discussed. Inadequacies of methods using spot samples are examined and the need to supplement present practice with continuous monitoring systems is emphasized.

Darling, J.A. "Explosives safety engineering in Canada"; MRP/MRL 77-60(OP); presented Nat Fire Pro Assoc Ann Meet, Washington; May 1977.

Under the Canada Explosives Act, the Department of Energy, Mines and Resources is responsible for safety regulations of explosives in

their manufacture, storage, sale, transportation on highways, and use by federal agencies. This report outlines briefly, Canada's immediate concerns, i.e., specifying limits of classification of less sensitive explosives known as blasting agents to separate them from (1) Class "A" explosives; and (2) fertilizers, oxidizers, and fuels.

de Korompay, V. "Determination of the in situ vertical permeability of mine backfills and waste materials"; MRP/MRL 77-96(J); submitted CIM Bull; Dec. 1976.

This paper presents operating principles, construction, and practical application of two permeameters — "twin rods" and "measuring electrodes" developed for measuring in situ permeability of hydraulic mine backfills and waste materials. Field tests indicate that these are inexpensive and practical tools for in situ investigation of porous materials and perform well in underground stopes where space and mobility are restricted.

Fisekci, M.Y. "Strata control instrumentation for coal mine design with special reference to hydraulic mining"; ERP/MRL 77-77(OP); presented 17th U.S. Symp Rock Mech, Snowbird, Utah; Aug. 25-27, 1976.

Recent developments are discussed in strata control instrumentation needed for fast moving faces of hydraulic mining in thick and steep coal seams. Results are presented from sub-level extraction in an hydraulic mine.

Harzer, H. and Geller, L.B. "German experience in hydraulic coal mining and its application to Canadian conditions"; ERP/MRL 77-70(J); submitted CIM Bull; Apr. 1977.

This paper endeavours to widen the scope of published data on hydraulic coal mining and is based on practical engineering and cost data gathered through contacts with West German designers and operators of hydraulic mines.

Herget, G. "Analysis of discontinuity orientation for a probabilistic slope stability design"; MRP/MRL 78-15(OP); presented 19th U.S. Symp Rock Mech, Lake Tahoe, Nevada; May 1-3, 1978.

The orientation of geologic discontinuities in hard rock in many cases determines the permissible angles for rock slopes. Graphical approaches are described to fit a two-dimensional or spherical normal distribution to discontinuity pole clusters and to determine the probability of sliding for different slope angles with the aid of the equatorial equal angle net.



Herget, G. and de Korompay, V. "In situ drainage properties of hydraulic backfills"; MRP/MRL 78-3 (OP); presented 12th Can Rock Mech Symp, Sudbury; May 23-25, 1978.

This paper discusses parameters influencing drainage behaviour of backfills. With a slimes content ( $\sim 38 \mu\text{m}$ ) of 10 - 25% the percolation rate drops below 5 cm/h. Further reductions occur due to cement addition, e.g., for a 30:1 tailings/cement mix the percolation rate can drop well below 1 cm/h within two days. Recently developed instrumentation is described for determining in situ percolation rates.

McCready, R.G.L. "The effects of solvent extraction organics on *Thiobacillus ferrooxidans*"; MRP/MRL 77-44(JOP); submitted Int J Hydrometall and presented Can Uran Prod Meet; Ottawa; May 19-20, 1977.

Use of bacterial leaching as a means of recovering metal values from low grade sulphide ores has resulted in numerous technological questions which require basic research prior to implementation of various processes in the mining industry. This study was designed to determine the effects of various concentrations of an organic extractant, a modifier and several diluents on iron oxidation by *Thiobacillus ferrooxidans*.

Moffett, D. "Some applications of specific-ion electrodes in the mining industry"; MRP/MRL 77-93(J); submitted Can Min J; March 1977.

Examples are given of three specific-ion electrodes for use in the chemical analyses of contaminants in mill effluents peculiar to the Elliot Lake area. The easy applicability of these specific-ion electrodes might provide impetus for investigating other uses for other electrodes in other mining operations.

Moffett, D. "Environmental aspects of thorium"; MRP/MRL 77-43(OP); presented Can Uran Proc Metall Comm, Ottawa; May 19-20, 1977.

Environmental impact of mining and milling uranium ores, and increasing concern for radioactivity hazards has resulted in ever-increasing constraints upon the uranium mining industry. The presence of thorium in the ore further adds to the complexity of the solid wastes and liquid effluents from the mining and milling of uranium ores. Only about 15% of the total radioactivity entering the mill in the ore leaves in the yellowcake concentrate; the remaining 85% is discharged in the tailings. This report examines the contribution of thorium and its extremely hazardous radium isotope  $^{228}\text{Ra}$  to this radioactive burden on the environment and expresses concern for the adequacy of surveillance procedures.

Moffett, D. "Identifying the isotopes of concern"; MRP/MRL 77-105(OP); presented Can Uran Prod Metall Comm Workshop on Radium, Ottawa; Oct. 17, 1977.

All too often the radiological impact of uranium tailings disposal is viewed only as a problem involving radium-226. However, 35 other

radioisotopes are present in the uranium and thorium decay series. These isotopes are discussed briefly with a view to identifying the isotopes of concern, and attempts to set an order of priority for developing information on specific radioisotopes.

Moffett, D. and Tellier, M. "Uptake of radioisotopes by vegetation growing on uranium tailings"; MRP/MRL 77-6(J); Can J Soil Sci; 57:4:417-424, 1977.

Tailings and plant tissue from four grass species from Elliot Lake, Ontario, were analyzed for uranium, thorium, radium-226, lead-210 and polonium-210. Except for creeping red fescue showing an anomalous uptake of lead-210, all four species showed similar uptake behaviour. Results and discussion are presented.

Moffett, D. and Tellier, M. "Vegetating the uranium mine tailings at Elliot Lake, Ontario"; MRP/MRL 77-19(J); J Soil Water Cons; 32:4:171-174; 1977 and submitted Eco/Log Week; Feb. 1977.

Current research on the vegetation of uranium tailings at CANMET's Elliot Lake Laboratory is outlined. A means of assessing the success of the grass cover by measuring plant yield and percent ground-cover is described. A survey of the uptake of radioactivity by grasses is included and indicates that uranium and radium-226 are concentrated to a significant degree, but do not appear to present any increased danger of radioactive exposure to man or environment.

Moffett, D. and Tellier, M. "Radiological investigations of an abandoned uranium tailings area"; MRP/MRL 77-54(J); submitted J Environ Qual; Apr. 1977.

Abandoned uranium tailings at Elliot Lake, Ontario provide a continuing source of radioactive water pollution. An investigation of one 16-ha pyrite-containing uranium tailings area is described. The analysis of solid samples showed the activities of  $^{226}\text{Ra}$ ,  $^{210}\text{Pb}$  and  $^{210}\text{Po}$  to be lower than could be accounted for by their radioactive decay since disposal. Uranium and thorium also had been significantly leached out of the tailings surface.

Mogan, J.P., Lawson, A., Stewart, D.B. and Dainty, E.D. "Diesel exhaust treatment, present and future"; ERP/MRL 77-110(J); North Min Ann Rev; Nov. 24, 1977.

This report describes briefly present and advanced technology for diesel exhaust treatment. The significant economic penalties of increasing ventilation rates led the authors to believe that the development of a system employing the optimum combination of advanced concepts, would ensure that underground dieselization continues to be economically viable.

Mogan, J.P., Stewart, D.B. and Bossert, J.A. "The evolution of a novel flametrap design: a case for testing with more sensitive mixtures"; ERP/MRL 77-

79(OP); presented Int Conf on Safety, Varna, Bulgaria; 1977.

A device to prevent exhaust backfires from propagating into an external flammable atmosphere is essential for diesel machines. A novel spaced-plate arrester design fulfilled all dimensional criteria for methane/air service, but failed proof-tests intended to ensure an adequate margin of safety. Subsequent tests indicated that the proof-test performance was symptomatic of a potential service failure. An investigation traced the failure mechanism to the method used to separate the element plates, and suggested a simple corrective modification.

Mogan, J.P., Stewart, D.B. and Dainty, E.D. "Oxidation of the nitric oxide fraction of diluted diesel exhaust"; MRP/MRL 77-117(R); submitted Can J Chem Eng; Jan. 1978.

The oxidation of nitric oxide in diesel exhaust was observed on a "macro" scale by determining the change in nitric oxide and nitrogen dioxide concentration with time for several exhaust levels in a 50-m<sup>3</sup> test cell. The measured concentration of nitric oxide decreased in accordance with published rate equations, but that of nitrogen dioxide increased at less than the corresponding rate. This deficiency of nitrogen dioxide in the gaseous phase is attributed to entrapment by other exhaust constituents.

Murray, D.R. "The influence of uranium mine tailings on tree growth at Elliot Lake, Ontario"; MRP/MRL 77-80(OP); presented Can Land Reclam Assoc Ann Gen Meet, Edmonton; Aug. 18-19, 1977.

A four-year study was made to determine the ability of coniferous trees to aid in reclamation of uranium tailings. White cedar, white spruce, jack pine, scotch pine and red pine were planted in vegetated and in bare tailings. Overall survival and growth was far below expectations from previous experience with grasses.

Pines were found to be the most suitable species for growth on uranium tailings. A comparison is drawn of reclamation suitability of the species and level of effort required for treatment.

Murray, D., Webber, B. and Larocque, E. "Reclamation of lower Williams Lake tailings area of Denison Mines Limited"; MRP/MRL 78-1(J); submitted CIM Bull; Aug. 1977.

The reclamation of a 2-ha uranium tailings area is described. Total costs were \$32,200 with vegetation establishment costs at \$13,700 per ha. This report provides a record of work for use in assessing the long-term suitability of given treatments.

Stewart, D.B., Mogan, J.P. and Dainty, E.D. "Diesel emissions and mine ventilation"; MRP/MRL 77-59(OP); presented 46th annual meeting and technical sessions, Mine Accid Prev Assoc of Ont., Toronto; May 25-27, 1977.

This paper summarizes diesel engine fundamentals, exhaust emissions and typical tailpipe concentrations. Mine sampling results and an evaluation of exhaust treatment systems are discussed. A review of changes in pollutant concentrations between the tailpipe and the mine exit is made and suggestions are given to reduce operator exposure.

Stewart, D.B., Mogan, J.P. and Dainty, E.D. "Canadian diesel experience"; ERP/MRL 77-89(OP); presented international diesel workshop, Niosh, Morgantown, W. Va.; Sept. 19-23, 1977.

This report summarizes diesel engine fundamentals, exhaust emissions, typical tailpipe concentrations, mine sampling results and exhaust treatment systems. A review is made of changes between the tailpipe and mine exit and suggestions are given to reduce vehicle operator exposure.

## TECHNOLOGY INFORMATION DIVISION

Dixon, Cyril "Better rails for Canadian trains"; MRP/TID 78-14(J); GEOS; Summer 1978.

CANMET scientists in cooperation with industry are investigation methods of improving wear resistance of premium rails. This paper describes two methods being investigated at CANMET - (1) adding alloying elements such as molybdenum, chromium, or vanadium to ordinary low carbon steel; (2) by thermomechanical treatment of "lean" alloy rail steels containing a small percentage of alloying elements.

Romaniuk, A.S. and MacDonald, R.J.C. "A national information service in mining, mineral processing and extractive metallurgy"; MRP/TID 78-10(OP); presented Ann Gen Meet, CIM, Vancouver; Apr. 23-27, 1978 and submitted CIM Bull.

This paper outlines CANMET's successful efforts to make optimum use of existing technological information. CANMET, with the nation's largest research and library resources in the minerals field offers through its in-house computerized mining file - MINTEC - technological information on mining, mineral processing and extractive metallurgy.

The Technology Information Division of CANMET backed by many facilities such as the library, in-house and commercial data bases, and the combined expertise of more than 260 professional staff, is able to provide answers to most enquiries quickly and thoroughly.

Taylor, G. "International projects expected to boost progress in coal industry"; TID 77-26(J); North Min Ann Rev; D10; Nov. 24, 1977.

This paper outlines Canada's participation, through the Department of Energy, Mines and Resources, in four coal projects of the International Energy Agency (IEA). The projects, whose main aim is to promote information transfer and technical cooperation on an international level

are: coal economics; resource and reserve assessment; international technical information exchange; and mining technology.

Taylor, G.W. and Kanasy, E. "Special challenges and problems in a technical information service serving the mineral and energy industries"; ERP/MRP/TID 78-5(OP); presented 6th Annual CAIS Conference, Montreal; May 10-13, 1978.

This paper describes technical information services in energy, mining, metallurgy and mineral processing at Canada Centre for Mineral and Energy Technology (CANMET) in Ottawa. The discussion focusses on efforts to improve technical communication to internal and external clientele in these fields through evolution of an all-embracing concept of information transfer in a research and development setting. Key elements of the information program are described, including: specialized machine-readable bibliographic files developed in-house; international technical information exchange in coal; and special marketing problems arising from the need to serve several different publics inside and outside government. The importance of informal scientific communication and interaction with the user is stressed.

Taylor, G. "Coal: the only option?"; ERP/TID 78-6(OP); presented Queen's University, Kingston, Ont.; Jan. 16, 1978.

This paper deals with the factors leading to the rapid re-growth of the Canadian coal industry. The following aspects are considered: characteristics of Canadian coals; resources and reserves; historical background; production, supply and demand; Canadian coal trade; utilization; new technologies; problems in coal development; mining; safety and health; manpower needs; transportation; environmental effects; government policies; and future development.

## SECTION 3

### AVAILABLE LABORATORY, DIVISIONAL AND PROGRAM REPORTS

#### MINERAL SCIENCES LABORATORIES

MRP/MSL 77-1(TR). Gilmore, A.J. "The ion-exchange removal of chloride anion from process effluents - A progress report"

MRP/MSL 77-4(TR). Mark, E. "Reference material CCU-1: Determination of copper-homogeneity test"

MRP/MSL 77-5(TR). MacEachern, E. "Pakistan graphite"

MRP/MSL 77-6(TR). Hole, J.C. and Craig, R.R. "Pakistan samples"

MRP/MSL 77-7(TR). Donaldson, E.M. "Reference material KC-1: Determination of lead-stability test"

MRP/MSL 77-14(TR). Pugliese, R.J. "Certified reference material CPB-1 - Chemical analysis for certification"

MRP/MSL 77-15(TR). Pugliese, R.J. "Certified reference material CZN-1 - Chemical analysis for certification"

MRP/MSL 77-16(TR). King, A.D. "Certified reference material CD-1 - Chemical analysis for certification of arsenic"

MRP/MSL 77-17(TR). Atkinson, J.A. "The determination of chloride in solutions in the presence of cyanide, thiocyanate and carbonate"

ERP/MSL 77-18(TR). Bowman, W.S. "Summary of DTA work on fireside ash deposits for CCRL"

MRP/MSL 77-20(TR). Cameron, W.H. "Progress report on wet processing of asbestos"

MRP/MSL 77-21(TR). Rolia, E. "Methods of analyses for sulphate, for individual thiosalts, and for elemental sulphur produced during the oxidation of sulphide ores"

MRP/MSL 77-24(TR). Hughson, M.R. "Image analysis studies of Nordic Lake tailings"

MRP/MSL 77-25(TR). Farrell, D.M. "Qualitative infrared analysis of tailing settling slime sample Z, Brunswick Mining and Smelting Corporation Ltd."

MRP/MSL 77-27(TR). Craig, R.R. "Pakistan chromite"

MRP/MSL 77-28(TR). Dutrizac, J.E. and Dinardo, O. "DTA analysis of cadmium sulphate"

MRP/MSL 77-29(TR). Cloutier, J.C. and Hole, J.C. "Certified reference material CD-1: Chemical analysis for certification"

MRP/MSL 77-32(TR). Mark, E. "Reference material MP-1: Determination of copper-stability test"

ERP/MSL 77-38(TR). Saint-Martin, N. "Hydrochloric acid leaching of an Elliot Lake uranium ore - a preliminary study"

MRP/MSL 77-39(TR). Brigham, R.J. and Kilpatrick, M.W. "Corrosion and wear during comminution. Part I. Effect of oxygen partial pressure"

ERP/MSL 77-40(TR). Saint-Martin, N. "Preliminary laboratory HCl - acetone leach tests on an Elliot Lake uranium ore"

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MRP/MSL 77-42(TR). Mark, E. "Reference material CZN-1: Determination of copper"

MRP/MSL 77-46(TR). Rolia, E. "Analyses for sulphate and individual thiosalts in tailing-pond water and in mill solutions from Brunswick Mining and Smelting, Bathurst, New Brunswick"

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MRP/MSL 77-48(TR). Hitchen, A. and Zechanowitsch, G. "The determination of zinc in zinc concentrates and ores: Part III: A comparison of two amperometric methods"

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MRP/MSL 77-53(TR). Lucas, B.H. and Prudhomme, P. "Progress report on the separation of uranium from leach liquors by single stage deep fluidized bed ion exchange"



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- MRP/MSL 77-129(TR). Collings, R.K. and Williams, A.J. "Conservation of mineral and energy resources through re-cycling — CANMET research"
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- MRP/MSL 77-141(TR). Chen, T.T. "Mineralogical examinations of the samples used in, and the products obtained from flotation tests"
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a pyritic Zn-Pb-Cu sulphide ore from Brunswick No. 12 mine"

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MacKinnon, D.J. "DCOM deep ocean mining study — A review and comparison of routes for processing manganese nodules"

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- MRP/MSL 77-242(TR). King, A.D. "Determination of chloride and hypochlorite in solutions by the silver sulphide ion - selective electrode"
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- MRP/MSL 77-248(TR). Mark, E. "Reference materials CZN-1 and CPB-1: Determination of tin"
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# AUTHOR INDEX OF CANMET PUBLICATIONS

1977/78

Author	Page No.
AHMED, S.M. ....	1,31,39
ATKINSON, J.A. ....	29
BANKS, G.N. ....	39
BANERJEE, R.C. ....	5,22
BARRON, K. ....	41
BEAULNE, J.M. ....	13
BEDNAR, J.S. ....	33
BELINKO, K. ....	5,7,23
BELL, D.R. ....	20
BELL, K.E. ....	30,35
BERRY, E.E. ....	11,15,31
BESHAI, J. ....	23
BIEFER, G.J. ....	5,6,20
BOSSERT, J.A. ....	25,26
BOTHAM, J.C. ....	39,40
BOWMAN, W.S. ....	8,9,29,34,35
BOYD, J.D. ....	20,21
BRAATEN, R.L. ....	22,23,24,39,40
BRANNEN, J.M. ....	13,14,35
BRIGHAM, R.J. ....	29,30,33
BROWN, T.D. ....	22,23,39,40
BRUCE, R.W. ....	11
BUCHANAN, R.M. ....	19,35
BUHR, R.K. ....	20
CABRI, L.J. ....	11,35
CALDER, P. ....	2
CALL, R.D. ....	45
CAMERON, W.H. ....	29
CAMPBELL, M.C. ....	7,31,41
CAMPBELL, R.A. ....	38,39
CAMPBELL, W.P. ....	5,38
CARETTE, G. ....	15,17,31,35
CARRIERE, P. ....	32,33
CARSON, D.W. ....	11,31
CHAKRAVORTY, R.M. ....	25,41
CHARETTE, D.J. ....	33,34
CHEN, T.T. ....	11,30,33
CIAVAGLIA, L.A. ....	23

Author	Page No.
CLARK, A.M. ....	11
CLOUTIER, J.C. ....	29
COATES, D.F. ....	2,42
COLLINGS, R.K. ....	7,11,30,32,35
COLUMBUS, T. ....	41
CRAIG, R. ....	29,31,32
CRUDEN, D. ....	2
CYR, T.J.R. ....	39
DAINTY, E.D. ....	27,41,42
DALTON, J.L. ....	4
DAOUST, A. ....	42
DARLING, J.A. ....	25
DAVIS, K.G. ....	37
DEAN, R.S. ....	34
DE KOROMPAY, V. ....	25,26,42
DENIS, J.M. ....	2,4,5,6,7,23,39,40
DESJARDINS, L.E. ....	18,30,33
DINARDO, O. ....	29,35
DINGLEY, W. ....	13
DIXON, C.F. ....	20,37,43
DONALDSON, E.M. ....	12,29,31,34
DRAPER, R.G. ....	8,39
DUREAU, R. ....	39
DUTRIZAC, J.E. ....	12,29,35
EBERSOLE, J.A.D. ....	41,42
EDWARDS, J.O. ....	20
FARRELL, D.M. ....	12,16,29,30,31,34
FAYE, G.H. ....	8,9,12,18,30,33
FENG, K.K. ....	25
FINES, H. ....	8
FISCEKCI, M.Y. ....	25
FLENGAS, S.N. ....	12
FRANCIS, D.J. ....	30
FREEMAN, C. ....	13
FRIEDRICH, F.D. ....	22,39,47
FROST, D.C. ....	22
FUNG, A. ....	39
FURIMSKY, E. ....	8,22,39

FYDELL, J. ....	30	KAIMAN, S. ....	34,35
GAINER, J.G. ....	24	KANASY, J.E. ....	28
GANGAL, M.K. ....	41	KAWATRA, S.K. ....	4
GARDINER, W. ....	39	KEARNS, J.B. ....	35
GELLER, L.B. ....	25,42	KELLY, F.J. ....	30,31,32,34
GEORGE, A.E. ....	1,5,22,23,24,39,40	KERBY, R.C. ....	14,35
GHOSH, A. ....	23	KHULBE, C.P. ....	2,4
GILMORE, A.J. ....	12,29,30,31,33	KHULBE, K.C. ....	23
GILMOUR, J.B. ....	37	KILPATRICK, M.W. ....	29,30
GODDEN, M.J. ....	37	KIM, H.S. ....	2
GOSSELIN, J.R. ....	18	KING, A.D. ....	29,32
GRAHAM, J. ....	32	KIRK, B. ....	41,42
GRANSDEN, J.F. ....	8,22,39,40	KLYMOWSKY, I.B. ....	16,17,35
GRANT, F. ....	41	KNIGHT, G. ....	41,42
GRANT, G. ....	42	KOWALCHUK, E. ....	39
GREEN, D.J. ....	12,13	KRIZ, J. ....	23
GRIFFITH, S.M. ....	17	LADANYI, B. ....	3
GYENGE, M. ....	1,3,41	LAFLAMME, J.H.G. ....	11,31,32,33,34
HAMER, C.A. ....	7,32,35	LAKSHMANAN, V.I. ....	13
HAMER, H.A. ....	1,22,25,39	LALONDE, C.R. ....	19,34
HAMPEL, K.F. ....	39	LANTHIER, P. ....	31
HAMZA, H.A. ....	1,22	LAROCQUE, G. ....	2,27,42
HAQUE, K.E. ....	32,33,35	LAU, I. ....	24
HARZER, H. ....	25	LAUFER, E.E. ....	16,20
HARRISON, V.F. ....	30	LAVIGNE, M.J. ....	37
HAYDEN, A.C.S. ....	22,23,40	LAWSON, A. ....	26
HAYSLIP, G.O. ....	16	LAWTON, B.E. ....	43
HEDLEY, D.G.F. ....	42	LECLERC, A. ....	13
HERGET, G. ....	1,2,3,5,25,26,41	LEE, G.K. ....	23,24,39,40
HERRMANN, W.A.O. ....	7,40	LEE, T. ....	42
HICKMAN, G.M. ....	39	LEEDER, W.R. ....	4,6,22,23,39,40
HITCHEN, A. ....	14,29,31,32,33,35	LETENDRE, A.A. ....	33
HODOUIN, D. ....	47	LEY, G.M.M. ....	2
HOEY, G.R. ....	13,14,18,31,33,36	LIVESEY, D.B. ....	42
HOLE, J.C. ....	29	LLOYD, T.A. ....	39
HORWOOD, J.L. ....	18	LOBAY, G. ....	42
HUGHSON, M.R. ....	16,29,33,34	LOGIE, R.B. ....	5,40
HUMENIUK, O.E. ....	40	LUCAS, B.H. ....	17,29,31,34
HUNT, G.A. ....	34	LUI, A.W. ....	14,31,36
HUTCHINGS, M.T. ....	13	LUTES, I.G. ....	22
INGLES, J.C. ....	7,9,31,41	MacDONALD, R.J.C. ....	28,43
JAMBOR, J.L. ....	13	MacEACHERN, E. ....	29,30
JANKE, L. ....	39	MacKINNON, D.J. ....	13,14,31,32,35
JOB, A.L. ....	43	MacPHERSON, D.R. ....	30,33
JOE, E.G. ....	13	MAGNY, J.G. ....	37
JONASSON, K.A. ....	6	MAJOR, G. ....	2
JORGENSEN, J.G. ....	39	MAKHIJA, R. ....	8,14



MALANKA, D. ....	9	PETRUK, W. ....	11, 16, 17, 31, 34, 35
MALETTE, M.J. ....	4	PICARD, J.L. ....	1
MALHOTRA, V.M. ....	6, 9, 11, 14, 15, 17, 19, 35	PICKWICK, K.M. ....	37
MALIK, L. ....	48	PILGRIM, R.F. ....	30, 33, 34
MANN, R.S. ....	23	PINARD, R.G. ....	31, 32, 34, 35
MANNING, P.G. ....	16	PINCH, W.W. ....	11
MARK, E. ....	18, 29, 30, 31, 32	PITEAU, D. ....	3
MARLON-LAMBERT, J. ....	4	POLLARD, W.A. ....	37
MARTIN, D. ....	3	PRICE, J.T. ....	6, 8, 23, 39
MASON, G.L. ....	8	PRUDEN, B.B. ....	2, 4, 5, 6, 23, 39, 40
MATHIEU, C. ....	18	PRUDHOMME, P. ....	29
MATHIEU, G.I. ....	1, 15	PUGLIESE, R.J. ....	29, 30, 32
McCREADY, R.G.L. ....	15, 26, 32	QUON, D.H.H. ....	6, 16, 17, 19, 35
McDONALD, R.D. ....	37	RAICEVIC, D. ....	35
McGOEY, J.T. ....	20	RALPH, M.S. ....	42
McGRATH, J.T. ....	8	RAMSDEN, J. ....	2
McINTOSH, D.G. ....	33	RANGANATHAN, R. ....	5, 39, 40
McNAMARA, V.M. ....	36	REEVE, D.A. ....	8, 22, 23, 39, 43
MERRILL, W.H. ....	2, 4	REGAN, R. ....	41
MIKHAIL, M.W. ....	40	REHDER, J.E. ....	22
MIKALSON, D. ....	41	REYNOLDS, V.G. ....	30
MILES, P. ....	41	RICHARDS, D. ....	1
MIRKOVICH, V.V. ....	3, 15, 16	RIPLEY, L.G. ....	18, 31, 35
MOFFETT, D. ....	7, 26, 41, 42	RITCEY, G.M. ....	16, 17, 31
MOGAN, J.P. ....	26, 27, 41, 42	ROBERTS, W.N. ....	20, 37
MOLOUGHNEY, P.E. ....	16, 30, 31, 32	ROLIA, E. ....	29, 30
MONTGOMERY, D.S. ....	5, 40	ROLKO, V.H.E. ....	15, 30, 32
MONTGOMERY, E.W. ....	39	ROMANIUK, A.S. ....	28
MONTGOMERY, W.J. ....	39	ROSENZWEIG, A. ....	11
MOORE, C.W. ....	41	ROWLAND, J.F. ....	32
MOORE, V.E. ....	37	ROSS-BROWN, D. ....	2
MUIR, W.B. ....	18	SABINA, A.P. ....	13
MUNRO, D.A. ....	37	SAGE, R. ....	2, 8, 41
MURRAY, D.R. ....	4, 8, 27	SAHOO, M. ....	38
MYSAK, L.P. ....	7	SAIDDINGTON, J.C. ....	17
NANDI, B.N. ....	7, 23	SAINT-MARTIN, N. ....	29, 33, 35
NOEL, G. ....	39	SARIN, N.K. ....	42
NEBESAR, B. ....	16	SAVIGNAC, D.G. ....	24
OWENS, D.R. ....	31, 32, 33, 34	SAWATZKY, H. ....	1, 5, 22, 23, 39, 40
PACKWOOD, R.H. ....	20, 23, 37	SCHNITZER, M. ....	17
PAINTER, K.E. ....	31	SCHUIT, G.C.A. ....	24, 40
PALMER, J. ....	30, 31, 32, 34	SEBISTY, J.J. ....	37
PARSONS, D.E. ....	37	SEKHAR M.V.C. ....	24
PARSONS, H.W. ....	16, 34, 35	SENESI, N. ....	17
PATMORE, D. ....	39	SEYMOUR, R. ....	41
PAYNE, C.J. ....	39	SHAH, A.M. ....	4, 6
PEPIN, R. ....	18	SHAHEEN, L.E. ....	34

SHARP, J.C. ....	2	TOEWS, N.A. ....	2,42
SILVER, S. ....	42	TOWNSEND, M.G. ....	13,17,18
SIRIANNI, G. ....	39,40	TREAFITIS, H.N. ....	41
SIROIS, L.L. ....	35	TREMBLAY, R.J. ....	16,18
SKEAFF, J.M. ....	34	TYSON, W.R. ....	21,37
SKELLY, H.M. ....	20	VIENS, G.E. ....	39
SLATER, W. ....	8	VOSIKOVSKY, O. ....	21
SLOWIKOWSKI, I. ....	43	WALLBANK, B. ....	22
SMILEY, G.T. ....	1,5,22,23,24,39,40	WALSH, J.H. ....	22
SOLES, J.A. ....	11,15,17	WANG, K.C. ....	37
SRAJER, V. ....	41,42	WANG, S.S. ....	35
STEFANICH, W. ....	41,42	WASHINGTON, R.A. ....	41
STEGER, H.F. ....	18,30,33	WEBBER, G. ....	27
STEWART, D.B. ....	41,42	WEBSTER, A.H. ....	13
STEWART, J.M. ....	11	WESTRA, P. ....	33
STEWART, M.J. ....	20,37	WHALEY, H. ....	24
STEWART, D.B. ....	26,27	WHALLEY, B.J.P. ....	24
STIMPSON, B. ....	1	WHEAT, T.A.V. ....	12,15,16,17,19,30,33
STURMAN, B.D. ....	13	WHEELER, C.M. ....	22
SUBRAHMANYAM, D.V. ....	18	WHITE, D.W.G. ....	21
SUTARNO, R. ....	8,9,18,34,35	WILKINS, A.L. ....	15,32
SZYMANSKI, J.T. ....	11	WILLIAMS, A.J. ....	30
TAPPING, R.L. ....	22	WINER, A.A. ....	19
TAYLOR, G.W. ....	27,28,43	WONG, A.S. ....	42
TELLIER, M. ....	26	WOOLF, R.L. ....	25
TERNAN, M. ....	5,23,24,40	YU, Y.S. ....	2,42
TERVO, R. ....	41	ZAHARY, G. ....	7,41
THOMPSON, E. ....	41	ZIMMERMAN, J.B. ....	19,34
THOMSON, R. ....	21	ZECHANOWITSCH, G. ....	29,30,31,32,33,34
TOBE, Y. ....	21		

# SUBJECT INDEX OF CANMET PUBLICATIONS

1977/78

	Page		Page
Acetone leach tests, uranium ore .....	29	Arseno-palladinite, Itabira, Brazil Cabri .....	11
Acetronitrile, copper-lead-zinc ore leaching with, mineralogical analysis ..	35	Arseno-palladinite, Stillwater complex, Montana Cabri .....	11
Acid control, pyritic uranium tailings, use of pentachlorophenol .....	32	Arsenopyrites, electron microprobe analysis of sample .....	31
Acid extraction processes Hamer .....	7	Athabasca bitumen, catalytic hydro- cracking Ranganathan .....	5
Acid leached clay, infrared analysis .....	31	Athabasca bitumen, geothermal matura- tion of George .....	22
Acid production, control of, from pyritic uranium tailings with pentachlorophenol McCready .....	15	Athabasca bitumen, hydrocracking Khulbe .....	4
Acidic northern waters .....	31	Athabasca bitumen, hydrocracking, cata- lysts Herrmann .....	7
Agglomeration, oxidized swarf and electric furnace fume .....	39	Athabasca bitumen, hydrocracking, chemical changes in nitrogenous materials Sawatzky .....	23
Alloys and metals crystal field effects Townsend .....	18	Athabasca bitumen, hydrocracking, pitch pyrolysis and gasification Sehkar .....	24
Alloy steels, high strength, cracking susceptibilities Biefer .....	5	Athabasca bitumen, hydrocracking, with and without catalysts Sawatzky .....	23
Alumina cement concrete, compressive strength, pulse velocity, high temper- atures Quon .....	6	Athabasca bitumen, thermal, catalytic hydro- cracking Ranganathan .....	5
Alumina, non-bauxite sources in Canada Winer .....	19	Athabasca bitumen, thermal hydrocracking Belinko .....	7
Aluminum alloy, corrosion .....	37	Athabasca bitumen, thermal hydrocracking Shah .....	4
Aluminum, determination of, in non-bauxite alumina Zimmerman .....	19	Athabasca bitumen, thermal hydrocracking Shah .....	6
Anaconda Caribou ore, quantimet analysis	32	Athabasca bitumen, thermal hydrocracking Khulbe .....	2
Annual meetings of Canadian Gold Metallur- gist and Canadian Mineral Processors ...	30	Athabasca oil sand bitumen, hydrocracking, use of tin catalysts Kriz .....	23
Annual progress report of Mineral Sciences Laboratories, 1976-77 .....	30	Athabasca oil sands, extraction and up-	
Antimony-arsenic ore Faye .....	8		
Arsenic, spectrophotometric determin- ation of, in concentrates and copper base alloys Donaldson .....	12		

grading .....	49	Blasting agents, classification, safety in Canada	
Athabasca tar sand, microbial separation of bitumen .....	49	Darling .....	25
Atomization of liquid metals, vacuum spray method .....	37	Blasting vibrations, in situ measurement of ground acceleration .....	41
Austenitic steels, hydrogen effects .....	37	Boiler tube samples, metallurgical examination .....	37
Backfill, height, prediction, pillar robbing .....	46	Borehole load cell, design and testing ...	42
Bacterial leaching of uranium, research McCready .....	15	Bornite, magnetic ordering at low temperatures, vacancy clustering Townsend .....	18
Bacterial leaching, sulphide ores, effects of solvent organics on bacteria McCready .....	26	Briquetting, hot study of Leeder .....	4
Beaverite and anglecite, electron microprobe analysis .....	31	Bulk blended concentrate, quantimet analysis .....	34
Beneficiated white mud (Kaolin), infrared analysis .....	29	Buttresses, Pit slope manual Richards, D. ....	1
Beneficiation characteristics, oolitic iron from Peace River district, Alberta Petruk .....	16	Cadmium sulphate, DTA analysis .....	29
Beneficiation of phosphate .....	35	Caking coals, defluidization of heated beds, detection Whalley .....	24
Binding of $Fe^{3+}$ , humic materials Senesi .....	17	Calcined zinc concentrate, electron microprobe studies .....	34
Bismuth, spectrophotometric determination of, in concentrates and non-ferrous alloys Donaldson .....	12	Calcium and magnesium, chelatometric analysis .....	35
Bitumen and heavy oils, separation of nitrogenous materials .....	39	Calcium, leaching of Berry .....	11
Bitumen, catalytic hydrotreatment of, coke deposits on catalyst surface Furimsky .....	22	Canadian Arctic, corrosion tests Biefer .....	6
Bitumen, geothermal maturation of Athabasca bitumen George .....	22	Canadian carbonization research .....	40
Bitumen, Great Canadian Oil Sands, thermal hydrocracking Khulbe .....	4	Canadian east coast oils, thermal maturation Sawatzky .....	5
Bitumen, hydrocracking, CANMET research Pruden .....	23	Canadian mining machinery, production and trade .....	41
Bitumen, separation of nitrogenous materials Sawatzky .....	1	CANMET contract research, monitoring ....	35
Blast furnace coke, high temperature behaviour Reeve .....	8	CANMET, information services Romaniuk .....	28
Blast furnace operations, iron oxide materials, tests Reeve .....	23	CANMET coke ovens, coke tumbler tests Leeder .....	6
Blast furnace slag Mason .....	8	CANMET, Review of activities, 1976-77 Bottom .....	7
		CANMET, Western Research Laboratory, coal beneficiation, history Whalley .....	24
		Carbon monoxide, monitoring for in underground coal mines Chakravorty .....	25

Carbonate hydrate mineral, infrared analysis .....	30	Chloride and hypochlorite ions, selective electrode analysis .....	32
Casting, strand casting of steel with a micromill Thomson .....	21	Chloride determination, in cyanide, thiocyanate, and carbonate .....	29
Casting, vacuum process, bronze plaque Edwards .....	20	Chlorination of complex sulphide ores, copper, lead and sulphur extractions ...	34
Catalytic gasification of pitch, from hydro-cracked bitumen Sekhar .....	24	Chlorination of complex sulphide ores, mathematical analysis .....	33
Catalytic hydrocracking, Athabasca bitumen Ranganathan .....	5	Chlorination of uranium and thorium ores .....	36
Catalytic hydrocracking, thermal, Athabasca bitumen Ranganathan .....	5	Chlorination of zinc-lead-copper ores, iron oxide dilution .....	34
Catalytic hydrotreatment of bitumen, coke deposits on catalyst Furimsky .....	22	Chlorination of zinc-lead-copper ores, particle size .....	34
Catalytic pitch gasification .....	40	Chlorination of zinc-lead-copper sulphide ores, nitrogen dilution .....	35
Catalysts, hydrotreating, effects of surface layering Kriz .....	23	Chlorination of zinc-lead-copper sulphide ores, oxidation of chlorinated calcines .....	35
Cement and concrete industry, energy and resource conservation Malhotra .....	15	Classification tests, laboratory, pit slope manual Gyenge .....	3
Ceramic powders, producing reactive and homogeneous Wheat .....	19	Coal ash analysis, X-ray fluorescence ....	39
Ceramics, ionically conducting, uses Wheat .....	19	Coal, beneficiation of high sulphur .....	40
Certification laboratories, coal mining equipment, Canada and overseas Bossert .....	25	Coal beneficiation, research at CANMET's Western Research Laboratory Whalley .....	24
Certification of reference materials Steger .....	18	Coal cleaning, pyrite oxidation in, detection by X-ray photoelectron spectroscopy Frost .....	22
Certification of zinc values, chemical analysis .....	33	Coal combustion, coal properties .....	46
Certified reference materials Faye .....	8	Coal, combustion studies .....	39
Certified reference materials Ingles .....	9	Coal drying, fluidized bed combustors ....	47
Certified reference material, arsenic, chemical analysis .....	29	Coal drying, fluidized bed combustors for Friedrich .....	22
Certified reference material, chemical analysis .....	29	Coal for steam boilers Nandi .....	23
Chalcopyrite bearing ores, oxidation, spectrophotometric assessment Faye .....	12	Coal gasification and liquefaction .....	43
Chalcopyrite concentrate, microscopic examination .....	33	Coal hydrogenolysis, coal upgrading, use of tin catalysts Kriz .....	23
		Coal industry, Canada's option Taylor .....	28
		Coal industry, economics, reserves, information, technology Taylor .....	28
		Coal in oil slurry, combustion .....	39



Coal, mineralogical analysis .....	35	Comminution, corrosion, wear and friction .....	33
Coal mine strata control, Western Canada, planning .....	41	Comminution, corrosion, wear, abrasion ...	33
Coal mine wastes, inventory .....	47	Comminution, review .....	47
Coal mining equipment, certification laboratories in Canada and overseas Bossert .....	25	Compressive strength high alumina cement concrete, high temperatures Quon .....	6
Coal mining under stored water .....	49	Computer programs, pit slope manual, shear sliding Sage .....	2
Coal samples, petrographic analysis .....	57	Concrete, cement and sulphur, fibre reinforcement Winer .....	19
Coal strip mine wastes, inventory, Saskatchewan .....	49	Concrete, core vs in situ tests for strength Malhotra .....	14
Coal sulphur, pyrite oxidation, detection of by X-ray photoelectron spectroscopy Frost .....	22	Concrete industry, energy and resource conservation Malhotra .....	15
Coals weathered, detection of oxidation by the microhardness, impression tests Nandi .....	23	Concrete materials and precast concrete, tests and construction methods, standards Malhotra .....	15
Coke formation, thermal hydrocracking of bitumen Belinko .....	5	Concrete, sulphur infiltrated Berry .....	11
Coke oven charges, partial agglomeration .....	39	Concrete, sulphur infiltrated, properties and performance Malhotra .....	15
Coke ovens, CANMET, coke tumbler tests Leeder .....	6	Concrete, sulphur infiltrated, stability Soles .....	17
Coke quality, coke charges, effects of particle agglomeration Leeder .....	23	Concrete, superplasticizers Malhotra .....	15
Coke tumbler tests, coke ovens, CANMET Leeder .....	6	Contamination, sample .....	30
Coking, carbonization variables .....	40	Cooperite, braggite vysotskite, electron microprobe analysis .....	34
Coking, coke charges, effects of particle agglomeration Leeder .....	23	Copiapite, electron probe analysis .....	32
Coking coal, tests .....	39	Copper alloys, zinc analysis .....	30
Combustion, chemical and physical aspects .....	39	Copper and nickel deposits, economic significance of Cabri .....	11
Combustion, coal for steam boilers Nandi .....	23	Copper concentrate, electron microprobe and quantimet analysis .....	33
Combustion of oil sand char .....	39	Copper-lead-zinc ore, image analysis .....	35
Combustion tests on coal .....	39	Copper-lead-zinc ore deposit, image analysis of sample .....	31
Comminution, corrosion and wear, oxygen partial pressure .....	29	Copper-lead-zinc ore deposit, mineralogical analysis of samples .....	31
Comminution, corrosion and wear, slurry density .....	30	Copper-lead-zinc ore deposits, image	
Comminution, corrosion, wear and abrasion .....	30		

analysis, samples .....	31	Defluidization of heated beds of caking coals, detection Whalley .....	24
Copper ore grinding, reduction of ball wear with additives Lui .....	14	Desulphurization of bitumen, electric arc furnace .....	40
Copper sulphides, desulphurization by dry chlorination Parsons .....	16	Diesel equipment, flame arresters .....	42
Copper-zinc ore, flotation, grinding media Petruk .....	16	Diesel equipment, flametrap design, safety Mogan .....	26
Corrosion behaviour, steels, pre-grinding Hoey .....	13	Diesel equipment in Canadian mines .....	41
Corrosion fatigue, crude oil pipelines, sub-critical crack extension Vosikovsky .....	21	Diesel exhaust, air humidity effects .....	42
Corrosion, high temperature metallic, chlorination of sulphides Lui .....	14	Diesel exhaust control .....	49
Corrosion of metals, chlorination of sulphides .....	36	Diesel exhaust control, fuel emulsification .....	48
Corrosion of mild steel, by ferric ion, control by potassium oxalate Subrahmanyam .....	18	Diesel exhaust, control, properties, Canada Stewart .....	27
Corrosion protection Fines .....	8	Diesel exhaust cooler-flame arrester .....	42
Corrosion, stainless steels, in sulphuric acid .....	33	Diesel exhaust emissions .....	42
Corrosion, stainless steels, sulphuric-hydrochloric acids and sulphuric-ferric chloride solutions .....	33	Diesel exhaust gases, treatment Mogan .....	26
Corrosion testing in Canadian Arctic Biefer .....	20	Diesel exhaust, levels of ambient particulates and carbon monoxide .....	41
Corrosion tests, Canadian Arctic Biefer .....	6	Diesel exhaust, nitric oxide analysis ....	42
Cracking susceptibilities, alloy steels, high strength Biefer .....	5	Diesel exhaust, oxidation of nitric oxide fraction Mogan .....	27
Crushing and grinding, bibliography .....	43	Diesel exhaust, sampler .....	41
Cupro-nickel alloys, high strength .....	38	Diesel exhaust, smokemeter .....	42
Cupro-nickel casting alloys, strength, casting, and welding of .....	37	Diesel exhaust, sulphuric acid .....	42
Cupro-nickel casting alloys, welding .....	38	Diesel exhaust temperatures, measurement .....	41
Cyanide, destruction of by ozonation, gold mill effluents Mathieu .....	1	Diesel exhaust, toxic gas control .....	42
Cyanided product, gold ores, mineralogical analysis .....	34	Diesel exhaust, vehicle mounted monitoring .....	41
Data bases, available to CANMET .....	43	Diesel exhaust, ventilation and control Stewart .....	27
Data presentation, mineral industry .....	46	Diesel exhaust, water scrubber and catalytic purifiers .....	48
		Diesels and coal production .....	41
		Diesel loaders, development for Canada ...	42
		Digger tooth for a dragline, examination .....	37
		DISCODAT program, Pit slope manual Cruden .....	2

Discontinuity orientation, rock slope stability, angles and slide probability Herget .....	25	K-ion conductor Quon .....	17
Disposal of thiosalt effluents, ocean disposal .....	30	Energy storage and conversion systems, thermal diffusivity of potassium magnesium Mirkovich .....	16
Dissolution of alumina from anorthosite lime soda sinter, leach variables .....	34	Exploding gases, test apparatus .....	42
Domain analysis programs, Pit slope manual Ramsden .....	2	Explosive atmospheres, low temperature effects .....	42
Double carbonate hydrate minerals, infrared investigation of Farrell .....	12	Explosives, classification, safety in Canada Darling .....	25
Drilling, instrumentation .....	47	Extraction of alumina, coal ash .....	32
Drying of coal, fluidized bed combustors for Friedrich .....	22	Extraction of alumina, from kaolinized sand by acid process .....	35
Drying, sulphide bearing minerals, microwave oven Steger .....	18	Extraction of alumina, from non-bauxite Canadian sources Winer .....	19
Dust collectors, respirable, size selection .....	41	Extraction of alumina, from non-bauxite sources, lime sinter process .....	35
Dust samplers .....	48	Extraction of alumina, sintered oxide mixtures .....	35
Dust, X-ray diffraction analysis .....	42	Failed worm gear, analysis of a black deposit on .....	37
Electrical energy storage, CANMET's role .....	33	Ferrous Concentrating and Sintering Inst., U.S.S.R. ....	43
Electrical properties of semiconductors, measurement, automatic .....	31	Ferrous foundry research in Canada, federally funded Buhr .....	20
Electrodeposited chromium, surface appearance Saiddington .....	17	Ferrous ground state, sulphide Leclerc .....	13
Electrowinning of copper, effect of chloride ion Lakshmanan .....	13	Filters and filter media Hamza .....	1
Electrowinning of lead, lead chloride solubility in organic solvents .....	32	Filtration Hamza .....	1
Electrowinning of lead, organic electrolytes .....	35	Fireside ash deposits, DTA work .....	29
Electrowon copper, effect on morphology of thiourea, LIX65N, and chloride ion Lakshmanan .....	13	Fireside ash deposits, high clay coals, X-ray diffraction analysis .....	32
Elements, identification of in radioactive grains .....	33	Flammability of a lacrimator mixture in air .....	42
Energy conservation, oil furnaces, use of emulsified water-in-oil fuels Whaley .....	24	Flammable gas detectors, tests .....	42
Energy dispersive analysis of minerals ...	31	Flocculants, commercial Hamza .....	1
Energy R & D, Canada .....	43	Flocculants, selection and evaluation Hamza .....	22
Energy Research Program, CANMET .....	43	Flocculation of froth flotation tailings .....	39
Energy storage and conversion systems,		Flotation circuits, sampling .....	35

Flotation of copper-lead-zinc ores, grinding media .....	47	Geophysics, Pit slope manual Herget .....	3
Flotation, of graphite in a graphitic ore .....	35	Glacial tills, mineralogical analysis ....	34
Flotation, recovering sphalerite grains Petruk .....	17	Glass and ceramics manufacture, nepheline syenite as raw material .....	35
Flotation, selective Bruce .....	11	Gold alloys, metal gas reactions .....	37
Flotation, sodium hypochloride as depres- sant Mathieu .....	15	Gold in concentrates and ores, determination by a fire assay atomic absorption method Moloughney .....	16
Flotation tests, mineralogical analysis of samples and products .....	30	Gold mill effluents, destruction of cyanide by ozonation Mathieu .....	1
Flotation, zinc-copper ore, grinding media Petruk .....	16	Grain size of gold bearing minerals, copper concentrate .....	34
Fluidized bed combustors for coal drying Friedrich .....	22	Graphite coating, anchor sample .....	31
Fly ash, Canada, production, uses, proper- ties Berry .....	11	Grinding Petruk .....	17
Fly ash, electron microprobe and X-ray diffraction studies .....	32	Grinding circuit for pyrite ore .....	47
Fly ash, properties of, iron in .....	31	Grinding circuit, sampling .....	48
Formula, stoichiometric, platinum group minerals Cabri .....	11	Grinding hematite ore, steel wear, temper- ature and pH effects Lui .....	14
Foundry research, ferrous, federally funded in Canada Buhr .....	20	Grinding media Bruce .....	11
Foundry sand, X-ray diffraction analysis .....	35	Grinding, sulphide ores .....	47
Fracture toughness testing McGrath .....	8	Grinding, zinc-lead-copper sulphide ore, thiosalts .....	30
Fuels, coal for steam boilers Nandi .....	23	Groundwater, Pit slope manual Sharp .....	2
Fuels, methanol as a replacement for oil or natural gas Hayden .....	22	Groundwater seepage, Pit slope manual Marlin-Lambert .....	4
Galena and lead, electron microprobe analysis .....	32	Hafnium, separation from zirconium Flengas .....	12
Galvanizing of steels, annealing pretreated parameters .....	37	Health, Safety Research Centre, uranium mines .....	46
Galvanizing research, CANMET, 1957-1977 ..	37	Heavy oils, desanding by hydrogenation ...	40
Gasification and production of heavy oils, tar sands .....	37	Heavy oils, separation of nitrogenous mater- ials Sawatzky .....	1
Gasification of pitch, from hydrocracked bitumen Sehkar .....	24	Heavy oils, slurry hydrocracking .....	39
		Hematite ore grinding, steel wear, tempera- ture and pH effects Lui .....	14
		High temperature behaviour of blast furnace coal - A review CANMET Rep. 77-60 .....	8

Hisingerite, allanite like phase, electron microprobe analysis .....	32	Hydrocracking, Athabasca oil sand bitumen with tin catalysts Kriz .....	23
Hot briquetting study using western Canadian coal samples CANMET Rep. 77-33 .....	4	Hydrocracking, control of sludge and coke deposition .....	40
Hydraulic backfills, in situ drainage properties Herget .....	26	Hydrocracking of Athabasca bitumen, changes in asphaltenes .....	40
Hydraulic backfills, in situ permeability, measuring instruments De Korompay .....	25	Hydrocracking of bitumen, CANMET research Pruden .....	23
Hydraulic backfills, radon control by chemical stabilization .....	42	Hydrodresserite, BaAl carbonate from silico-carbonatite, Montreal Island, P.Q. Jambor .....	13
Hydraulic coal mining, bibliography .....	43	Hydrogen permeation, monitoring .....	37
Hydraulic coal mining, thick steep seams, West Germany and Western Canada .....	42	Hydrogenation of coal, destructive .....	43
Hydraulic coal mining, West Germany and Canada, costs and engineering Harzer .....	25	Hydrometallurgical treatment of uranium ores, thorium analysis .....	34
Hydraulic fluids, fire resistant tests ...	42	Hydrotreating catalysts, effects of surface layering Kriz .....	23
Hydrochloric acid-fluosilicic acid leaching, extraction of alumina from anorthosite .....	35	Information services, CANMET Romaniuk .....	28
Hydrochloric acid leaching, alumina from anorthosite .....	34	In situ field tests, Pit slope manual Gyenge .....	3
Hydrochloric acid leaching, uranium ore ..	29	Iron and aluminum-silicon alloys, production crushing test for powders Skelly .....	20
Hydrochloric acid leaching, uranium ore ..	33	Iron (Fe <sup>3+</sup> ) binding by humic materials Senesi .....	17
Hydrochloric acid leaching, uranium ores, mathematical analysis .....	30	Iron catalysts, Athabasca bitumen, hydrocracking Herrmann .....	7
Hydrocracked Athabasca bitumen, benzene, toluene, xylene source .....	40	Iron, determination in non-bauxite alumina Zimmerman .....	19
Hydrocracked Athabasca bitumen gasolines .....	40	Ironmaking, smelting ore-carbon briquettes .....	39
Hydrocracked heavy gas oil, nitrogenous parts .....	40	Iron mine tailings, use in building bricks .....	32
Hydrocracking, Athabasca bitumen Khulbe .....	4	Iron ore deposits, smelting process, Peace River deposits, Alberta Gransden .....	22
Hydrocracking, Athabasca bitumen, catalysts Herrmann .....	7	Iron ore, magnetic concentration, alkaline roasting Ritcey .....	17
Hydrocracking, Athabasca bitumen, chemical changes in nitrogenous materials Sawatzky .....	23	Iron ore, image analysis .....	35
Hydrocracking, Athabasca bitumen, pitch pyrolysis and gasification Sehkar .....	24	Iron ore mill samples, image analysis ....	33
Hydrocracking, Athabasca bitumen, with and without catalysts Sawatzky .....	24	Iron ore reference materials, preparation and certification .....	35
		Iron ores, aluminum analysis .....	35



Iron ores, methods for sodium, potassium and metallic iron .....	34	Linepipe, steel, design for Arctic Bell .....	20
Iron ores, total iron analysis .....	35	Linepipe steels, microstrength and toughness of high strength steel Boyd .....	20
Iron oxide materials, blast furnace tests Reeve .....	23	Liquid fuels from coal .....	40
Iron sulphides, desulphurization by dry chlorination Parsons .....	16	Machining swarf, recycling .....	37
Iron, yield as affected by hydrogen Tobe .....	21	Magnesium alloy .....	30
Isomertieite, electron microprobe analysis .....	31	Magnetic ordering at low temperatures, of bornite, vacancy clustering Townsend .....	18
Joint mapping, Pit slope manual, terrestrial photogrammetry Herget .....	3	Magnetite ore, radioactive phase analysis .....	32
K-slump tester .....	31	Manganese nodules, processing .....	31
Laser interferometer Carson .....	11	Maturation studies, Canadian East Coast oils Sawatzky .....	5
Lateral displacement characteristics Fines .....	8	Mechanical properties, Pit slope manual Gyenge .....	1
Leaching of radioactive materials .....	35	Mercury content in massive galena and sphalerite, electron microprobe analysis .....	33
Leaching of sulphur and calcium, from sulphur infiltrated concrete Berry .....	11	Meta-aluminite, electron microprobe analysis .....	33
Leaching test, anorthosite sinter, mathematical analysis .....	33	Metals and alloys, crystal field effects Townsend .....	18
Leaching tests on anorthosite sinter, mathematical analysis .....	30	Methane gas, coal mines, control and monitoring Chakravorty .....	25
Lead-antimony sulphosalts, preparation ...	31	Methane gas control, water infusion, Canada .....	46
Lead-arsenic-bismuth minerals, electron probe analysis .....	32	Methane gas, underground coal mines, monitoring Chakravorty .....	25
Lead sulphides, desulphurization by dry chlorination Parsons .....	16	Methane roof layering control .....	46
Lead-zinc ore fractions, X-ray fluorescence on line analysis Kawatra .....	4	Methanol, as a field replacement for oil or natural gas Hayden .....	22
Lead-zinc sulphide ores, chloride metallurgy Parsons .....	16	Methanol for stationary source combustion .....	40
Liberation of a zinc-lead-copper ore, grinding media .....	34	Microalloyed steels, heat affected zone toughness (2) .....	46
Lignite combustion, sulphur retention in ash .....	40	Microalloyed steels, notch toughness, weld heat affected zone .....	48
Lime sinter process, alumina production, Canadian anorthosite .....	32	Mill circuit solutions, determination of polythionates and thiosulphate Makhija .....	14
Limesoda sinter process, Canadian anorthosite, chemical aspects .....	31	Milling of steels, determination of	

parameters for HSLA steels by simulation and pilot tests		Nitrogenous materials, separation of, from bitumen and heavy oils	
Stewart .....	20	Sawatzky .....	1
Mills, energy consumption, Canada		Noise dosimetry .....	41
Joe .....	13	Non-bauxite alumina, Canadian sources	
Mill waste water, chemical analysis, specific ion electrodes		Winer .....	19
Moffett .....	26	Non-bauxite alumina, determination of aluminum, silicon, calcium, iron and titanium	
Mine ventilation, digital computers .....	41	Zimmerman .....	19
Mine wastes, remote monitoring, Canada (5) .....	47	Non-bauxite alumina, extraction from Canadian sources	
Mineral wool manufacture .....	48	Winer .....	19
Mineralogical characteristics, of oolitic iron from Peace River district, Alberta		Non-bauxite alumina materials	
Petruk .....	16	Hamer .....	7
Mineral waste		Nontronite and ferruginous opal, Peace River iron ore deposit, Alberta	
Collings .....	11	Petruk .....	16
Mineral waste resources, of Canada		Nordic Lake tailings, image analysis .....	29
Collings .....	7	Northern oils, maturation studies .....	40
Mine waste inventory		Notch ductility, structural steels, high strength	
Murray .....	8	Campbell .....	5
Mining effluents, determination of polythionates and thiosulphates		Nuclear waste storage, some thermophysical properties of rocks	
Makhija .....	14	Mirkovich .....	16
Mining wastes in Quebec		Nuclear waste storage, thermal conductivity of host rocks	
Collings .....	7	Mirkovich .....	15
Molybdenum-alumina catalysts, surface chemistry, denitrogenation and desulphurization activity		Nuclear waste storage, thermal diffusivity and thermal expansion of rocks	
Khulbe .....	23	Mirkovich .....	16
Molybdenum sulphide, photoelectricalchemical and redox reactions .....	31	Oil conservation, in home heating	
Monitoring, Pit slope manual		Hayden .....	22
Larocque .....	2	Oil samples, analyses .....	39
Mossbauer data, calibration		Oil sand bitumen, Athabasca, hydrocracking with tin catalysts	
Carson .....	11	Kriz .....	23
Mossbauer effect, data index, 1975		Oil sand tunnel, gases .....	45
Townsend .....	18	Oil sands, open pit mining .....	42
Mullite, synthesis of, freeze dried process .....	30	Oil sands, underground mining .....	47
Multiseam mining, uranium mining .....	42	Oil sands tunnel, gas observations .....	41
Nickel mines, Norilsk Kombinat, U.S.S.R. ....	43	Oil sands tunnel, hydrocarbon and gas analyses .....	42
Nickel sulphide, sublattice magnetization of, temperature dependence		Olivines, electron probe analysis .....	32
Hutchings .....	13	Open pit mine, support and monitoring of slopes .....	47
Nitric acid leaching, uranium ore, removal of radium 226 .....	34		

Open pit mining, environmental impact mining .....	46	Pipeline steels, microstrength and toughness of high strength steel Boyd .....	20
Ore grinding, steel corrosion in Hoey .....	13	Pit slope economics (4) .....	45
Oxidation, chalcopryrite bearing ores Faye .....	12	Pit slope manual, DISCODAT program Cruden .....	2
Oxidation, detection of in weathered coals by the microhardness, impression test Nandi .....	23	Pit slope manual, Domain analysis programs Ramsden .....	2
Oxidation, of nitric oxide in diesel exhaust Mogan .....	27	Pit slope manual, Geophysics Herget .....	3
Oxidation, of pyrite in coal, detection of by X-ray photoelectron spectroscopy Frost .....	22	Pit slope manual, Groundwater seepage Marlon-Lambert .....	4
Oxidation of reference ores, monitoring ..	30	Pit slope manual, In situ and laboratory tests Gyenge .....	3
Oxidation of reference ores, monitoring ..	33	Pit slope manual, Joint mapping, terrestrial photogrammetry Herget .....	3
Oxidation of sulphide ores, analysis for sulphate, individual thiosalts, and sulphur .....	29	Pit slope manual, Groundwater Sharp .....	2
Oxidation, sulphide minerals, pyrite, chalcopryrite pyrrhotite Steger .....	18	Pit slope manual, Mechanical properties Gyenge .....	1
Ozonation, destruction of cyanide in gold mill effluents Mathieu .....	1	Pit slope manual, Monitoring Larocque .....	2
Pakistan chromite .....	29	Pit slope manual, Perimeter blasting Calder .....	2
Pakistan graphite .....	29	Pit slope manual, Plane shear analysis Major .....	2
Pakistan samples .....	29	Pit slope manual, Retaining walls Richards .....	1
Palladium arsenide, electron probe analysis .....	31	Pit slope manual, Shear sliding, computer programs Sage .....	2
Palladium tellurides, electro probe analysis .....	32	Pit slope manual, Soil tests Gyenge .....	3
Pellets, concentrates with different CaO/SiO <sub>2</sub> ratios .....	39	Pit slope manual, Structural geology Herget .....	5
Pentachlorophenol in drainage waters, analysis .....	30	Pit slope manual, Structural geology Martin .....	3
Perimeter blasting .....	42	Pit slope manual, Vegetative reclamation Murray .....	4
Perimeter blasting, Pit slope manual Calder .....	2	Pit slope manual, Vegetative reclamation Murray .....	8
Petroleum coke in Canada .....	45	Pit slope project (5) .....	45
Physical metallurgy journals .....	43	Pit slope project, 1972-77 .....	41
Pipe, linepipe, design of steels for Arctic Bell .....	20	Pit slope stability, design .....	42
Pipelines, crude oil, corrosion fatigue, subcritical crack extensions Vosikovsky .....	21	Pit slope stability, structural geology ..	41

Pit slope stability, tests, sampling, mechanical properties (6) .....	41	Radioactive isotopes in uranium tailings Moffett .....	26
Plane shear analysis, Pit slope manual Major .....	2	Radioactive ores, treatment at CANMET Ritcey .....	17
Platinum group minerals Cabri .....	11	Radioactive ores, uranium and thorium Ingles .....	9
Platinum group minerals Cabri .....	11	Radiochemical analysis, available to uranium producers .....	41
Platinum group minerals, Onverwacht, gen- kinite Cabri .....	11	Radium 226, research on at CANMET Ritcey .....	17
Platinum group minerals, Onverwacht, Pt- Fe-Cu-Ni alloys Cabri .....	11	Radium 228 hazards, in uranium mining and milling Moffett .....	26
Plume dispersion Whaley .....	24	Radon daughter measurement, sampling time and filter pore size effects .....	41
Plume dispersion, at an oil sand refinery Whaley .....	24	Radon daughters, dust, instrumentation (2) .....	48
Plume dispersion, flaring of sour gas at a sour gas plant Whaley .....	24	Radon, Finnish mines .....	41
Porous and friable materials, cross section through .....	37	Radon 222 progeny, measurement of air con- centrations, alpha particle spectrometry Tremblay .....	18
Porphyry deposits, Highland Valley, B.C., exploration Jambor .....	13	Rails, wear resistance, steels Dixon .....	28
Power consumption of raw coal .....	39	Rare-earth oxides, electron probe analysis .....	31
Pozzolans, B.C. ....	47	Reclamation of uranium tailings, costs Murray .....	27
Process effluents, ion exchange removal of chloride anion .....	29	Recovery of iron from tailings .....	35
Pulse velocity, high alumina cement con- crete, high temperatures Quon .....	6	Recovery of lead from pyritic concentrate, hydro-metallurgical .....	46
Pyrite, uranium ore, image analysis .....	31	Recycling, CANMET research .....	30
Quartz analysis, gravimetric sampling ....	41	Recycling of steel mill wastes .....	39
Quartz analysis, X-ray diffraction .....	41	Recycling, zinc conservation Edwards .....	20
Quartz dust analysis, X-ray diffraction ..	42	Reference material, antimony analysis ....	30
Quartz dust, infrared calibration curves .....	30	Reference material, antimony analysis ....	31
Quartz dust reduction, ore breakage tests .....	41	Reference material, bismuth analysis .....	31
Quartz infrared standards, quantimet size analysis .....	34	Reference material, chemical analysis (2) .....	31
Quartz on micropore filters, infrared analysis .....	34	Reference material, chemical analysis ....	32
Quartz particle size, infrared spectro analysis .....	30	Reference material, copper analysis .....	29
		Reference material, copper analysis .....	30
		Reference material, copper homogeneity test .....	29

Reference material, copper stability test .....	29	Rock slope stabilization, rock anchors, fibrous shotcrete, wire mesh .....	48
Reference material, gold and silver analysis .....	30	Rock slope stabilization, rock anchors, shotcrete (3) .....	49
Reference material, lead analysis (2) ....	34	Rolling, simulation and pilot testing for milling HSLA steels	
Reference material, lead stability test ..	29	Stewart .....	20
Reference material, tin analysis .....	32	Roof bolts, oil sand tunnel (2) .....	41
Reference material, vanadium analysis ....	31	Rotational shear sliding, Pit slope manual, Computer programs	
Reference material, zinc analysis .....	31	Sage .....	2
Reference material, zinc, iron, copper, lead, calcium, magnesium analysis .....	30	Satellite imagery	
Reference materials, certification of Steger .....	18	Murray .....	8
Reference materials, lead, zinc, iron and copper analysis .....	32	Selenium, spectrophotometric determination of in concentrated and copper metal	
Reference materials, zinc analysis (2) ...	33	Donaldson .....	12
Reference ores		Separation of uranium from leach liquors, fluidized bed ion exchange .....	29
Faye .....	12	Shaft electric furnace (2) .....	39
Reference ores, recommended values for Faye .....	9	Shale samples, X-ray fluorescence analysis .....	39
Reference ores, zinc and copper analysis .....	33	Silicon, determination in non-bauxite alumina	
Removal of metals, chloride raffinates ...	33	Zimmerman .....	19
Removal of toxic metals, chloride raffinates .....	30	Silver bearing chalcopryrite and chalcopyrite, electron microprobe analysis ...	34
Removal of toxic metals, chloride raffinates (2) .....	31	Silver bearing tennantites, electron microprobe analysis .....	31
Retaining walls, Pit slope manual		Silver-bismuth-selenium, electron microprobe analysis .....	32
Richards .....	1	Silver in ores and concentrates, determination by a fire assay atomic absorption method	
Revegetation of asbestos mine wastes .....	48	Moloughney .....	16
Revegetation of mine wastes, Quebec .....	49	Silver jarosite ore, electron probe studies .....	31
Revegetation, sulphide mine wastes (2) ...	48	Size reduction of uranium ore, radiation protection .....	34
Roasting, alkaline, iron ore, magnetic concentration		Slags, use of Canadian for insulation	
Ritcey .....	17	Winer .....	19
Robinsonite, electron microprobe analysis .....	31	Slope failures, case histories (2) .....	45
Rock anchors, tests (2) .....	46	Slope stability, blasting effects (6) ....	48-9
Rock slope design, plane shear failure (2) .....	45	Slope failures, probability .....	45
Rock slope design, resistance step path ..	45	Slope stability, design and computer analysis (3) .....	46
Rock slope stability, discontinuity orientation, angles and slide probabilities		Slope stability economics .....	49
Herget .....	25	Slope stability, groundwater .....	45



Slope stability, groundwater, drainage, artificial support (6) .....	47	needs White .....	21
Slope stability monitoring .....	42	Stereomicroscopic photography of samples .....	37
Slope stability monitoring .....	47	Strata control instruments, thick and steep seams of coal hydraulically mined Fisekci .....	25
Slope stability monitoring (4) .....	49	Stress analysis, finite element, computer .....	42
Slope stability monitoring, data handling (4) .....	46	Stress measurements, Creighton mine .....	41
Slope stability monitoring, geology (2) ..	45	Strontiodresserite, Sr-Al carbonate, Montreal Island, P.Q. Jambor .....	13
Slope stability, retaining walls .....	46	Structural geology, Pit slope manual Herget .....	5
Slope stability, shear strength, deformation, tests, design (4) .....	46	Structural geology, Pit slope manual Martin .....	3
Slope stability, structural surveying and geology, drilling, rock mass classifi- cation (13) .....	48	Structural steels, high strength, notch ductility and weldability Campbell .....	5
Slope stability, wedge failures .....	46	Sublattice magnetization, nickel sulphide Hutchings .....	13
Smelting process, iron ore deposits of Peace River, Alberta Gransden .....	22	Sulphide bearing minerals, drying, micro- wave oven Steger .....	18
Sodium beta alumina, preparation of freeze dried Green .....	12	Sulphide mine wastes, pedological studies (3) .....	45
Soil tests, Pit slope manual Gyenge .....	3	Sulphide minerals, oxidation of pyrite, chalcopyrite, pyrrhotite Steger .....	18
Sphalerite, electron microprobe analysis .....	33	Sulphide ores, bacterial leaching, effects of solvent organics on bacteria McCreedy .....	26
Spontaneous combustion, hydraulic coal mines, carbon monoxide and infrared de- tection Chakravorty .....	25	Sulphides ores, SEM analysis .....	37
Stability of barium/radium sulphate sludges .....	45	Sulphide tailings .....	47
Stainless steel .....	33	Sulphide and sulphosalt, electron micro- probe analysis .....	33
Statistical evaluation of analytical data (2) .....	35	Sulphides and sulphosalts, copper-molybdenum ores, electron microprobe analysis .....	32
Statistical evaluation of analytical data, computers .....	34	Sulphides chlorination, metals testing ...	31
Steel, cracking of air-melt, vacuum degassed .....	37	Sulphides, electron probe analysis .....	32
Steel, corrosion of mild steel by ferric ion, control of potassium oxalate Subrahmanyam .....	18	Sulphosalt, electron microprobe analysis .....	33
Steel rolling, forces .....	37	Sulphur, determination in petroleum pro- ducts Makhija .....	8
Steels, corrosion behavior, pregrinding Hoey .....	13	Sulphur, leaching of Berry .....	11
Steels, HSLA steels for the north, charac- teristics, metallurgy, new equipment			

Sulphuric acid leaching, alumina from anorthosite .....	34	Thermal hydrocracking, Athabasca bitumen Shah .....	2
Superplasticizers, in concrete Malhotra .....	9	Thermal hydrocracking of Athabasca bitumen, chemical changes .....	39
Supports for coal mines, geomechanics, U.S.S.R. ....	43	Thermal hydrocracking, bitumen, Great Canadian oil sands Khulbe .....	4
Tailings, for brick production .....	30	Thermal hydrocracking of bitumen .....	40
Tailings, image analysis .....	34	Thermal hydrocracking of bitumen and heavy oils, pressure vessel design .....	37
Tailings, in situ permeability, measuring instruments De Korompay .....	25	Thermal hydrocracking, catalytic, Athabasca bitumen Ranganathan .....	5
Tailings, mineralogical analysis .....	35	Thermal hydrocracking, of bitumen, coke formation Belinko .....	5
Tailings pond waters, sulphate and individual thiosalts analysis .....	29	Thermal insulation, from waste container glass .....	35
Tailings, seepage control .....	49	Thermal insulation, use of Canadian mineral materials, slags and tailings Winer .....	19
Tailings settling lime, infrared analysis .....	29	Thermal maturation, Canadian East Coast oils Sawatzky .....	5
Tailings, use of Canadian for insulation Winer .....	19	Thorium hazards, in uranium mine and mill wastes Moffett .....	26
TEM examination and identification of small crystalline particles Laufer .....	20	Titanium, determination in non-bauxite alumina Zimmerman .....	19
Temper embrittlement, control, surface analysis Tyson .....	21	Titanium, reaction with sulphur vapour Dutrizac .....	12
Tennantite and sphalerite, copper concentrate, analysis .....	34	Treatment of uranium ore and mill wastes, CANMET research .....	31
Terrestrial photogrammetry, Pit slope manual Herget .....	3	Underground mine environment, monitoring systems .....	46
Tetrahedrite, electron microprobe analysis .....	32	Uranium concentrates (11) .....	30
Tetrahedrite, electron microprobe analysis .....	33	Uranium concentrates (2) .....	31
Tetrahedrite/tennantite and bornite, electron microprobe analysis .....	33	Uranium concentrates (6) .....	32
Tetrahedrite/tennantite, electron microprobe analysis .....	33	Uranium concentrates (6) .....	33
TGA and DTA analysis of ore samples .....	35	Uranium concentrates .....	34
Thermal diffusivity, measurement Mirkovich .....	3	Uranium content, in zircon, electron microprobe analysis .....	32
Thermal hydrocracking, Athabasca bitumen Belinko .....	7	Uranium extraction Moffett .....	7
Thermal hydrocracking, Athabasca bitumen Khulbe .....	2	Uranium leaching by bacteria, research McCready .....	15
Thermal hydrocracking, Athabasca bitumen Shah .....	4	Uranium mine expansion, Ontario, environ-	

mental impact .....	41	Warm air heating system, tests .....	40
Uranium mines and mills, hygiene survey ..	48	Waste disposal, revegetation, coal and gypsum mines, Canada (3) .....	49
Uranium ore, treatment, conservation, pol- lution control, at CANMET Ritcey .....	17	Waste embankments, permafrost, Canada ....	46
Uranium tailings, control of pyritic acids with pentachlorophenol McCready .....	15	Waste rock as concrete aggregate, iron mines .....	35
Uranium tailings, decontamination and uses .....	35	Waste utilization of slags and tailings from Canada for insulation Winer .....	19
Uranium tailings, hazards of thorium and radium 228, monitoring Moffett .....	26	Wear of balls in copper ore grinding, re- duction of Lui .....	14
Uranium tailings ponds, radiological in- vestigations Moffett .....	26	Weldability, structural steels, high strength Campbell .....	5
Uranium tailings, process and environmental research Moffett .....	7	Welding line pipe, microstructure of heat affected zone (2) .....	37
Uranium tailings, radioactive isotopes in grass cover Moffett .....	26	Welds in stainless steels, chromium and molybdenum extremes, microprobe analysis .....	37
Uranium tailings, radium 226 and other ha- zardous radioactive isotopes Moffett .....	26	Welds, galvanized tubular poles, factors affecting .....	37
Uranium tailings, reclamation and costs Murray .....	27	Wet processing of asbestos .....	29
Uranium tailings, tree growth on Murray .....	27	X-ray analysis, graphite support grids for the electron microscope Packwood .....	20
Uranium tailings, vegetation of Moffett .....	26	X-ray fluorescence on line analysis, lead- zinc ore fractions Kawatra .....	4
Uranium waste management .....	42	X-ray spectroscopy, electron microscope, graphite support grids .....	37
Vanadium, determination in petroleum pro- ducts Makhija .....	8	Zinc-aluminum alloys, porosity in deformed .....	37
Vanadium (V) oxide, high temperature analy- tical uses, critical review of Nebesar .....	16	Zinc chloride catalysts, Athabasca bitumen, hydrocracking Herrmann .....	7
Vegetative reclamation, Pit slope manual Murray .....	4	Zinc chloride, promoted Fe catalysts, Athabasca bitumen, hydrocracking Herrmann .....	7
Vegetative reclamation, Pit slope manual Murray .....	8	Zinc concentrate, superpanned tip, electron microprobe analysis .....	32
Vegetative stabilization, uranium tailings Moffett .....	7	Zinc concentrates, microscopic and electron microprobe studies .....	32
Ventilation planning for uranium mines ...	46	Zinc conservation, recycling for, uses Edwards .....	20
Violarite, natural spinel structure Townsend .....	18	Zinc-copper ore Bruce .....	11
Warm air furnace, performance .....	39	Zinc-copper ore, flotation, grinding media Petruk .....	16

Zinc deposited from acid sulphates, cadmium effect .....	35	Parsons .....	16
Zinc deposits, morphology of as electrowon from sulphate and chloride electrolytes MacKinnon .....	14	Zinc ore and tailings, zinc analysis .....	32
Zinc deposit structures, from acid sulphate electrolytes, antimony and glue additives MacKinnon .....	14	Zinc ores, zinc analysis (2) .....	29
Zinc deposit structures, from acid sulphate electrolytes, effect of lead MacKinnon .....	14	Zinc recovery, water treatment Gilmore .....	12
Zinc-lead sulphide ores, chloride metallurgy		Zinc sulphides, desulphurization by dry chlorination Parsons .....	16
		Zirconium, separation from hafnium Flengas .....	12





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