CANMET REVIEW 1977-78

CANMET REPORT 78-12

Canada Centre for Mineral and Energy Technology,
Department of Energy, Mines and Resources,
Ottawa, Canada.

Published under the authority of
The Honourable Alastair Gillespie
Minister of Energy, Mines and Resources

Available in Canada through

Authorized Bookstore Agents
and other bookstores

or by mail from

Canadian Government Publishing Centre
Supply and Services Canada
Hull, Quebec, Canada K1A 0S9

CANMET
Energy, Mines and Resources Canada,
555 Booth St.,
Ottawa, Canada K1A 0G1

Catalogue No. M38-13/78-12 Canada: $2.25
ISBN 0-660-10143-2 Other countries: $2.70

Price subject to change without notice.

Cover Photo - One problem in coal combustion is the release of atmospheric pollutants. At the Canadian Combustion Research Laboratory at Bells Corners, CANMET is studying ways to reduce these pollutants. The technician in the foreground is measuring electrical resistivity of fly ash which affects performance of electrostatic precipitators used in power plants

FOREWORD

Launching of the Canada Centre for Mineral and Energy Technology took place with the appointment of the first director in 1901. Of the five original functions of the new branch, the main surviving one is to "make such chemical, mechanical, and metallurgical investigations as are found expedient to help the mining and metallurgical industry of Canada". From the beginning also, the branch has been entrusted with providing a technical knowledge base to aid the federal government in formulating policies and in advising regulatory agencies.

During the seven decades of its existence, the branch has expanded its facilities and greatly diversified the scope of its scientific activities. Its principal aim, however, is still to help the industry make an even greater contribution to the national economy. Emphasis during the years has changed from time to time in efforts to overcome shortages of one mineral or another.

Coal and petroleum problems have, from the start, been the subjects of investigation. Now energy research is given added emphasis. The spectre of impending shortages of oil has spurred efforts to improve recovery and utilization of domestic supplies, to develop new and innovative sources, and to substitute alternative forms of energy. Changes in priorities have been effected without serious disruption under the matrix system of management, replacing projects and activities in the Minerals Program as they are completed by ones in the Energy Program. Another change too has been the trend to contracting out research — more than 20% of the branch's work is now contracted out to industry and universities.

It is recognized that developing new technology by itself is of little practical value unless the information can be passed along to industry. The branch has devoted increased resources to implementation of an effective technology transfer program, including workshops and demonstration trials. Considerable progress has been made in establishing an efficient information service. This combines a well-stocked reference library and the publication of research reports for distribution to the general public with the services of an expanded technical enquiries section in which information officers with on-line access to computer-stored data bases complement the efforts of research scientists in providing technical information.

D.F. Coates,
Director-General

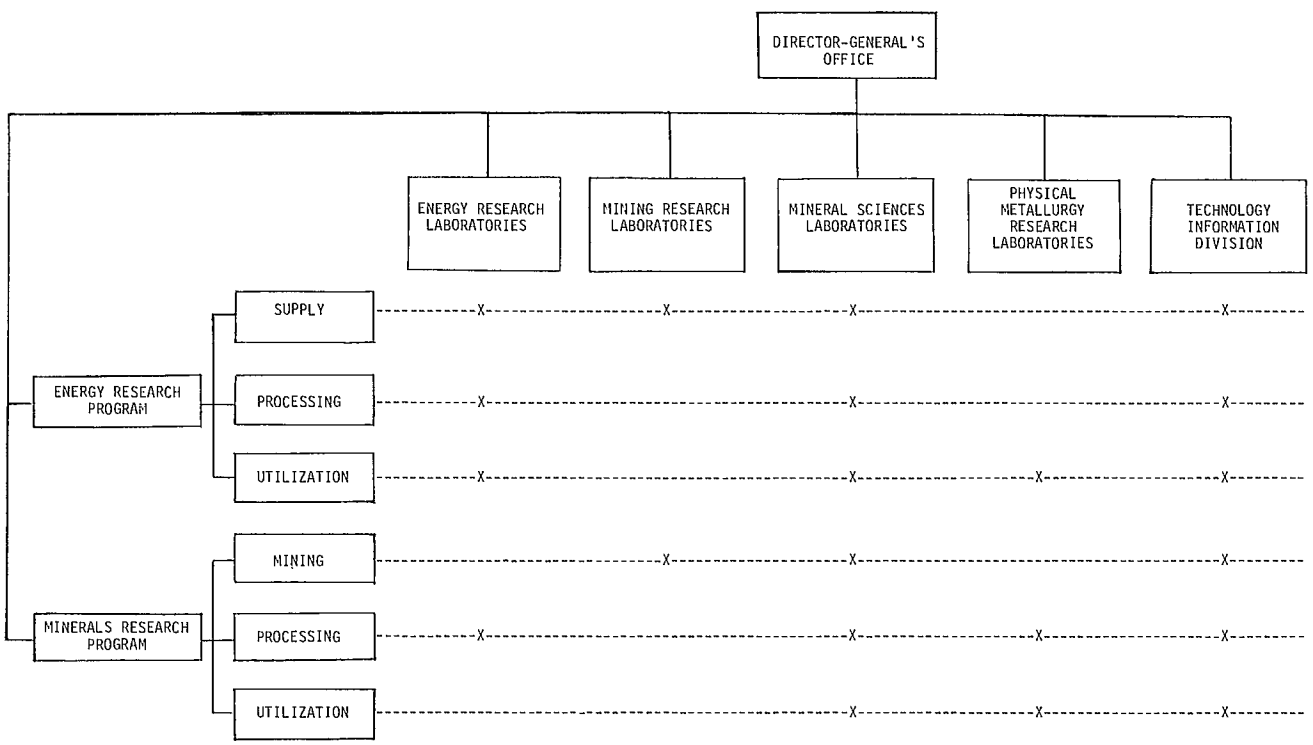
CANMET MANAGEMENT 1977-78

Director-General — D.F. Coates

Deputy Director-General — V.A. Haw

RESPONSIBILITY CENTRES

Energy Research Program.....D.A. Reeve
Minerals Research Program.....W.A. Gow
Energy Research Laboratories.....B.I. Parsons
Mineral Sciences Laboratories.....R.L. Cunningham
Mining Research Laboratories.....T.S. Cochrane
Physical Metallurgy Research Laboratories.....W.H. Erickson
Technology Information Division.....J.E. Kanasy



CONTENTS

CONTENTS (cont'd.)

INTRODUCTION

Assuring effective utilization of minerals and energy, developing new technology, and assuring the availability of energy from innovative as well as traditional sources are the prime functions of the Canada Centre for Mineral and Energy Technology. Work is proceeding through contracts and in-house to find ways of improving the recovery, processing and utilization of energy resources. Research focuses on developing alternative resources which lie untapped — oil sands and heavy oils — and on substituting coal for oil and gas for the generation of electrical energy. In minerals technology, the focus is on exploitation of deep-lying, low-grade, complex deposits, recycling of waste products, minimizing environmental damage, and generally maintaining Canada's competitive position.

CANMET also contributes to the department's Minerals and Energy Programs by providing a technical knowledge base for developing government policies. It provides independent test information and advice to many regulatory agencies, and it disemminates both research and advanced technology information to the scientific and industrial community at large.

Activities of the branch are planned and implemented through a Minerals Research Program and an Energy Research Program operating across five functional units. The latter comprise Mining Research Laboratories, Mineral Sciences Laboratories, Physical Metallurgy Research Laboratories, Energy Research Laboratories, and Technology Information Division. These are referred to as MRL, MSL, PMRL, ERL, and TID respectively.

The program directors are responsible for developing priorities and objectives and for issuing the detailed work statements, budgets and schedules which specify what is to be accomplished, when it will be performed and which functional unit will be accountable.

The functional units are under the management of laboratory chiefs who, in response to program demands, are responsible for determining who within their own group will perform the work, where it will be done and how it will be accomplished. In addition, functional management is responsible for ensuring that the disciplines, skills and equipment needed to meet program objectives are available when required.

This review presents highlights during the 1977-78 fiscal year of the various activities and projects which comprise the two programs. The text is organized according to program structure rather than functional units, thus drawing together related research activities taking place in the various laboratories.

ENERGY RESEARCH PROGRAM

The Energy Research Program of CANMET forms an important part of the EMR Energy Program, the general objective of which is "to ensure the availability of, and to promote the effective use of energy resources for Canada". CANMET projects fall within two Activities, namely Energy Resource Determination and Energy Technology Development with about 90% of available manpower resources in the latter. Highlights from many of these projects for fiscal year 1977/78 are presented below.

The major thrusts of the federal energy research and development (R & D) program are in energy conservation, fossil fuels (conventional oil and gas, tar sands and heavy oils, coal), nuclear, renewables, and transportation and transmission. CANMET projects attempt to respond to objectives in all of these areas, but the main emphasis is on fossil fuels. Incremental funds from the recommendations of the Interdepartmental Panel on Energy R & D have allowed CANMET to initiate programs with Canadian industry, often on a 50/50 shared basis, that are now approaching the stage at which expensive demonstration-scale plants will have to be contemplated. Of the fossil fuels incremental funds available, 87% are within CANMET's responsibility, which includes co-ordinating and reviewing all federal effort in this area. In addition, all energy R & D in the Science and Technology Sector of EMR is now co-ordinated by CANMET.

Energy conservation studies continued to focus on more efficient burners for home heating, improved automobile efficiencies and fuel additives.

While no work is going on in CANMET on in situ recovery methods for oil sands and heavy oil, a small effort is continuing on oil sands mining, and methods are being assessed for bitumen-sand separation. The one-barrel a day hydrocracking pilot plant has yielded encouraging results with Athabasca bitumen and Lloydminster heavy oil; further progress was also made on catalyst bases for upgrading these materials by catalytic hydrocracking.

A contract program to adapt advanced mining techniques to Western Canadian coal deposits was established and, also in the field of coal production the high-clay Hat Creek coals from British Columbia were cleaned successfully in the 10-ton per hour coal beneficiation pilot plant developed by EMR.

Coal utilization R & D assumed new importance during the year because coal, which now contributes less than 10% of Canada's total energy demand, is seen as an important substitute for oil in the short to medium term. The CANMET coal conservation program has mainly been addressed to techno-economic process studies which are now leading to proposals for demonstration plants, especially for coal-to-electricity processes using combined (gas turbine and steam) generating cycles in conjunction with fluidized-bed coal combustion or low-Btu coal gasification systems.

A modest start in research on renewables has been made in biomass conversion with contracts dealing with wood waste gasification; these contracts are to be expanded in future years. The focus of research and development in materials for energy is the physical metallurgy of new steels and fabrication methods for natural gas pipelines under Arctic conditions, but some effort continued in materials for heavy water plants and for electrical storage and conversion.

Studies on coal slurry pipelining and liquid natural gas transmission were CANMET's contributions to the general area of energy transportation and transmission.

ENERGY RESOURCE DETERMINATION

The federal government has a broad mandate in the national interest for determining nuclear and fossil fuel resources. In recent years this has been extended to include reserves as well as resources as a further basis for rational policy formulation and resource management. The contribution of CANMET has traditionally been to assess the quality of nuclear and fossil fuels, with emphasis on uranium and coal. Studies are also conducted on heavy oils, bitumen from oil sands, and peat.

It is becoming increasingly apparent that economic exploitation of resources on a long-term planned basis requires regulation based on computerized reserve data banks. The prime example is uranium because overall assessment on a national scale is facilitated by compulsory reporting by all mining

and exploration companies of drill core data to federal authorities; it is therefore possible to independently assess reserves for any given set of economic, cost and market conditions. Furthermore, because production and sales are regulated, it is possible to assess and forecast production capabilities. This is more difficult to do for coal because much of the resource and reserve data is not disclosed to federal authorities by the provinces or by private coal companies. Coal production is governed by more normal marketing forces. Assessing coal reserves is made easier for EMR by participation, sometimes with Departments of Regional Economic Expansion (DREE) or Industry, Trade and Commerce (ITC) in provincial coal inventory agreements which provide direct access to all relevant information.

CANMET's long experience with coal and its expertise in mining is enabling two new factors — mineability and economic production — to be added to the criteria at present used for assessing reserves. This will be increasingly difficult as the relatively straightforward surface-mined lignite deposits of Saskatchewan are depleted and efforts must start on the more difficult coals of the prairies, foothills, and mountain regions, many of which must be mined by underground methods.

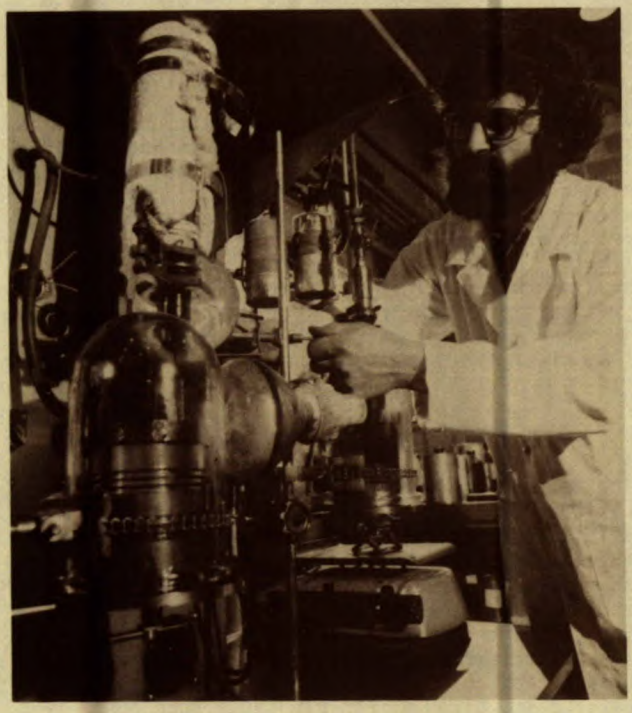


Fig. 1 - Flash equilibrium is used to determine yields from hydrocracking of oil sands bitumen and heavy oils. The Synthetic Fuels Research Laboratory is studying ways to get more oil from these low-grade petroleum resources.

Uranium Resource, Reserve, and Production Assessment — CANMET is responsible to EMR's Uranium Resource Appraisal Group (URAG) for the annual evaluation of actual uranium ore reserves. Development of computer techniques begun in 1976 to interpret industry-provided basic drill hole data was continued; the sophisticated geostatistical techniques now being applied allow CANMET to make an independent appraisal of reserves which provides a valuable comparison with calculations made by the various mining companies.

A data base of mining and economic factors pertinent to uranium production is being assembled. Together with cost models now under development, this allows mineability and cost criteria to be applied to known reserves and a good estimate of future potential production to be made for each uranium mining property in Canada.

A noteworthy feature of URAG's work is the close cooperation between provincial officials, mining companies and departmental staff. This results in an exchange of information and ideas which contributes greatly to understanding Canada's potential uranium supplies.

Assessment of Coal Quality — Knowledge of coal quality is particularly important when assessing coal reserves because the market value of coal can vary by a factor of about 10 depending on its particular organic and inorganic constituents and structure. Furthermore, coal-burning plants are often designed for a particular type of coal and may be unable to use coal of a different quality; this may influence whether a particular coal mine should go into production.

CANMET maintains full laboratory facilities for the range of tests accepted as indicating coal quality. As well as assessments made for industry on a cost-recovery basis, CANMET has participated with the provinces in assessing the quality of their coal deposits by provision of analytical services and by interpretation and data management. In particular, the ongoing evaluation of Saskatchewan lignite resources has reached the stage of a complete computer data file on coal quality, and the Canada — Nova Scotia inventory of coal resources was expanded to include undersea deposits up to five miles off-shore in the Sydney coal-field. Coal quality data provided by CANMET are an integral part of the National Coal Inventory being developed by the departmental Coal Assessment Group.

Other related projects involved commercial coal quality evaluation in Eastern and Western Canada related to fuel conversion plans of electric utilities, and development of test standards to allow more accurate and complete coal quality assessment in view of changing usage and environmental constraints.

There is a growing awareness in North America of the energy potential of peat, the mother of coal. Through contracts, an order of magnitude assessment of Canadian peat fuel resources was completed, and mineability studies undertaken. Peat de-

posits capable of supporting a 50-MW thermal electric plant were identified. In some locations, costs compare favourably with those for conventional fuels.

Coal Mining Methods – To determine how much of the coal resources can be recovered, feasible mining techniques and appropriate economic factors must be identified. Current mining techniques are being evaluated to determine those most suitable, in particular, longwall methods now used in Eastern Canada are being appraised for their relevance to mountain and prairie seams in the West. The advantages of such methods include relatively low labour requirements, high productivity and, in the right circumstances, minimal surface disturbance. If favourable, these appraisals will be followed by field trials.

Determining and minimizing the cost of mining coal is of paramount importance when new mines are being evaluated. After considerable in-house assessment, CANMET has determined that the powerful economic computer model developed by ERDA – now the U.S. Department of Energy – is potentially appropriate for evaluating Canadian coal mines. When modified for Canadian practice, this new tool will considerably help the difficult task of assessing the costs and benefits of a given coal mining operation.

Oil Sands and Heavy Oils – Characterization studies, which were devoted mainly to Athabasca bitumen this year, help in assessing potential product quality and elucidating reaction mechanisms and problems encountered in upgrading processes. The work is now being extended to Lloydminster and Cold Lake heavy oils as well as to coal-derived liquids. The major components investigated are hydrocarbons and nitrogen and sulphur-bearing compounds.

Bitumen contains high levels of undesirable sulphur-containing components. Analytical techniques have been developed to study these compounds in products containing large amounts of interfering olefins. The application of the techniques to naphtha fractions was also investigated. The work is being extended to higher boiling fractions.

During the calendar year, 17,500 determinations were performed in the analytical laboratory. Most of the analyses were on samples from the hydrocracking pilot plant; determinations included insolubles, sulphur, nitrogen, vanadium, ash, and distillation range, among others. In addition, an extensive evaluation of pilot plant gases by gas chromatography has been undertaken. To a lesser extent, samples from catalyst testing experiments as well as from other laboratories were analyzed.

Work was also carried out on behalf of several outside organizations. In connection with a continuing resource evaluation project, five samples of crude oil and one of natural gas, all from Ontario, were analyzed. The work also included contract work for the New Brunswick Power Commission, 77 mine air samples from provincial mine inspectors, participation in the Canadian Government Specifications Board exchange program, analyses of lubricating oils for the National Research Council, and evaluating fuel oils for the Department of Public Works and other clients.

ENERGY TECHNOLOGY DEVELOPMENT

A major portion of CANMET's energy research effort is directed to the Energy Technology Development Activity with the principal objective of ensuring adequate technical capability for the supply, processing and use of energy. The main efforts in this activity are directed to conservation, oil and gas, coal and peat, and energy transportation with lesser efforts in the nuclear and electrical fields.

Responsibilities include coordinating research, development and demonstration; funding or otherwise stimulating R & D in the private sector and in universities; performing R & D in the support of departmental objectives; and encouraging the application of successful research projects to industrial use.

Conservation Technology

Reduction of the demand for oil, particularly in the Atlantic provinces, has been the focus of CANMET's R & D effort in conservation technology. The scope of projects directed towards the use of coal in industrial heat processes was expanded this year. Emphasis was also placed on strategies to conserve oil through improvement of residential heating efficiency and automobile fuel economy. Effort has continued for the substitution of other indigenous fuels for oil and has been extended to examining the use of low-grade fuels.

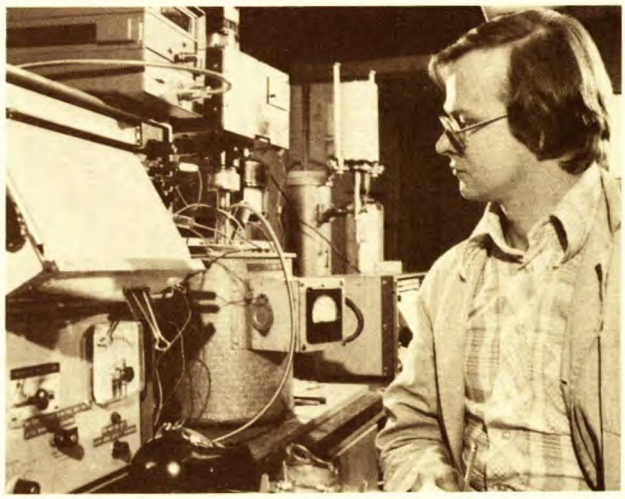


Fig. 2 - A technician uses a Gieseler plastometer to assess plastic behaviour of a coal at high temperatures – an important criteria in determining its value for making metallurgical coke.

Fig. 3 - This photograph shows instrumentation and controls for CANMET's hydrocracking process that could improve yield from oil sands and heavy oils

Most of this work was conducted by the Canadian Combustion Research Laboratory (CCRL) at the Bells Corners site at Ottawa. One aspect culminated in the signing of contracts for designing Canada's first coal-fired fluidized-bed heating plant, to be located in P.E.I. Coal-in-oil as an alternative fuel to oil in existing thermal power boilers and blast furnaces has also been introduced on a trial basis.

Domestic Heating – Besides being close to the hearts and pocketbooks of nearly all Canadians, domestic usage accounts for nearly 20% of the total Canadian energy demand. Much of this demand is in the form of oil and gas for which there is a threat of shortage and the certainty of higher prices.

On-going studies in a group of Ottawa homes to assess the effects of various energy conservation strategies under real-life conditions were extended to include cyclic pollution emission characteristics. These data on NO, SO_2, CO and soot were used in conjunction with previous results to establish the effect of the strategies on both fuel conservation and emissions.

Both fuel conservation and emission reduction can be optimized by using newly developed low-excess air burners; however, in the case of existing home installations where retrofitting is not possible, several alternative strategies have proven both effective and economic. These include improving burner performance, thermostat cut-back, reduced firing rate, use of a positive chimney damper, and an increase in thermostat control units. Fuel reductions up to 20% and emission reductions from 3 to 28% were shown to result from these measures.

Fuel Additives – Since 1973 when energy prices began to escalate, many fuel additives claiming to conserve energy, reduce pollution and prevent soot formation have been put on the market. To determine the validity of some of these claims, three fuel-oil additives were evaluated in 1977 in a research project carried out jointly by CANMET and the Department of National Defence (DND). The additives were burned in a small oil-fired package boiler that was specially instrumented to measure minor changes in boiler efficiency, combustion performance and pollutant emissions. Both No. 2 fuel oil and No. 6 fuel oil were burned to establish baseline conditions for these experiments.

In an extension of the above project, a number of water-oil emulsions containing up to 20 vol % water were evaluated to identify any benefits that might result from water additions to these two grades of fuel oil.

Automobile Fuel Economy – Tests have been conducted at CCRL since 1973 to determine the effects of various parameters on automobile fuel economy. Parameters examined have been advanced spark ignition engine technology, effect of increased emission standards, vehicle velocity, trip length, fuel quality, and Canadian climatic conditions, with particular emphasis on cold winter temperature effects. Since 1976, most of the actual tests have been conducted by private industry under contracts let by CCRL.

Tests were conducted on five 1977 model automobiles to determine their fuel economy and pollutant emission degradations with decreasing ambient temperature, thus better representing performance under Canadian climatic conditions. Tests were run in a temperature controlled dynamometer room at 70°F, 40°F, 10°F and -10°F. Vehicles with engines having advanced combustion technology, specifically the computer-controlled lean-burn engine, showed less deterioration in fuel economy

Fig. 4 - Improved home furnace efficiency provides economic benefits for individual homeowners and for Canada as a whole

and emissions than engines employing conventional technology using catalytic converters to clean up emissions. A Volkswagen Rabbit Diesel achieved fuel consumptions ranging from 50 mpg (80.5 km/gal) for cold start city-suburban driving, to 75 mpg (120.7 km/gal) at a constant speed of 35 mph (56.3 km/h).

Increased Utilization of Low-Grade Canadian Coals — Reliable combustion performance criteria for low-grade coals and coal rejects are essential to burn these fuels successfully in conventional coal-fired plants. Coal characteristics such as high moisture and high ash in combination with high sulphur content significantly affect equipment availability and efficiency, but most operational problems with these coals can be minimized through pilot-scale research that can be extrapolated with reasonable confidence to full-scale equipment.

The major impetus in this area has been supplied by evaluating various qualities of coal from the Hat Creek deposit in B.C. The studies were conducted in a pilot-scale boiler at CCRL and on the basis of these results a full-scale trial burn was undertaken at the Battle River power station in Alberta. Although this work has indicated the possibility of burning Hat Creek coal of reasonable quality in steam generators as large as 750 MW, the lack of direct experience with high-clay coals in equipment of this size would suggest a prudent size limitation of the first unit between 300 and 500 MW. Other fuels such as petroleum coke and a beneficiated Obed-Marsh coal have been assessed for combustion performance and recommendations made as to special measures required.

Coal-Oil Slurries — Pilot-scale studies of the feasibility of burning coal-oil slurries conducted

Fig. 5 - The automobile is an important user of energy as well as a major contributor to air pollution. Ways to improve fuel efficiency and reduce emissions are being studied; here lead emissions are being measured to determine the efficiency of pollution control devices.

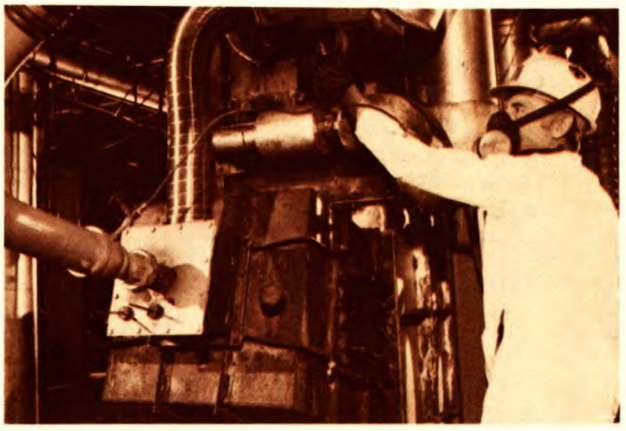


Fig. 6 - The combustion characteristics of coals assume greater importance as the use of coal for power generation grows. An engineer is making an adjustment to the pilot-scale research boiler at the Canadian Combustion Research Laboratory.

by CCRL have shown the viability of this technology. CCRL staff members are acting as scientific authorities on a demonstration study in which coal-oil slurries are being burnt in a 10-MW generating facility at Chatham, N.B. Preliminary combustion trials with a 10 wt % coal-oil slurry have been conducted and it is planned to extend the trials to cover the range 0-40 wt %.

Fluidized-Bed Combustion — Fluidized-bed combustion (FBC) is an emerging technology which is capable of:

- burning low-grade coals and waste materials such as coal washery rejects and wood waste;
- burning high-sulphur fuels with minimal emission of sulphur oxides; and
- being adapted to combined cycles which give a high efficiency of conversion from fossil fuel to electricity.

For these and other reasons, FBC is expected to have considerable impact on the Canadian energy picture and has been given high priority in the CANMET energy program. The major effort is directed at the installation of a demonstration plant on each major application, but it has been recognized that demonstration plants are likely to require R & D support facilities.

To fulfill this need, a pilot-scale FBC combustor of 24-cm inside diameter has now been brought to the operational state and is fully instrumented. Initial trials have been performed on coaly waste from a Hat Creek deposit with a view to further extracting aluminum from the ash residue. Plans for the coming year include evaluations of the combustion performance of tar sands coke and a selection of Canadian coals representative of those which will fuel demonstration plants now under consideration.

The highlight of the FBC program has been initiation of conceptual design contracts for an atmosphere fluidized-bed heating plant to satisfy steam

demands for the DND base at Summerside, P.E.I. The economics of co-firing wood chips together with Eastern Canadian coals containing up to 20% ash and 5% sulphur will be determined. It is intended to negotiate additional contracts early in the new fiscal year for competitive conceptual designs of an entire heating plant incorporating two FBC boilers and all necessary ancilliaries, from fuel and limestone receiving depot to stack.

Other applications of FBC in coal drying and combustion of wood waste were examined. Combustion of coal washing rejects containing 70% ash has been indicated as technically feasible, thus presenting a means of converting a disposal problem into a source of energy. Preliminary analysis of combustion efficiency of a proprietary FBC system for burning wood waste at Chapleau, Ontario, has confirmed the potential of this application.

The coming year will see initiation of negotiations with provincial utilities concerning the potential for heat and electrical power generation at specific sites utilizing FBC technology.

Control of Combustion-Generated Air Pollution — The quality of fuel burned and the technology selected for controlling atmospheric emissions of combustion products have a pronounced effect on the efficiency of energy conversion processes. Control measures may include flame modifications to prevent generation of pollutants, transformation of combustion products into species removed by available abatement equipment, and selection of adequate stack heights to optimize dispersion in regional air sheds. These measures may be applied alone or in combination to ensure that environmental criteria for point impingement concentrations are not exceeded.

Fig. 7 - Pilot-scale fluidized-bed combustion unit; this new technique is a way of burning poor quality fuels such as low-grade coals and waste materials more efficiently and cleanly

Studies have been conducted within CCRL in cooperation with Fisheries and Environment Canada and Ontario Hydro. They have been directed respectively towards use of gas phase measurement as an indicator of sulphur neutralization by ash constituents in coal and to evaluation of additives for enhancing collection efficiency of electrostatic precipitators when burning low sulphur coal. The latter work has important ramifications to the development of fluidized-bed technology, a characteristic of which is the production of low sulphur fly-ash.

Oil and Gas

CANMET's oil and gas R & D has centred on the recovery and processing of the oil sands and heavy oils of Western Canada. The deposits of oil sands that can be mined by present methods are limited and new mining techniques will be needed in the future.

Also, existing and projected oil sands plants use a bitumen upgrading process that produces high-sulphur coke, which cannot be burned without difficulty in meeting environmental standards. A CANMET process eliminates coke production by using high pressure thermal and catalytic hydrogenation to increase the yield of synthetic liquid fuels.

Oil Sands Mining — CANMET maintains an awareness service to keep the department up-to-date in current and potential practice in oil sands mining. Where this identifies areas to which CANMET's particular mining expertise can apply, appropriate research and development is undertaken. This year the Saline Creek diversion tunnel — the first true underground excavation in oil sands — was driven. This afforded a practical study of the application of underground mining methods in oil sands, one way in which the potential of this vast resource may be realized in future. Tests were conducted by CANMET to measure the behaviour of oil sands during excavation, including factors such as gas emission; future work will include permeability measurements and evaluation of hydraulic cutting. Other work in hand includes assessments of open pit excavation technology applied to oil sands mining.

Separation of Bitumen from Sand — Development of alternative separation processes has continued with further evaluation of the cold-water and surfactant methods. Considerable contract support was given to the study of solvent extraction parameters and mechanical upgrading parameters for oil-sand separation processes. Sensitivities to solvent losses were evaluated as well as the extraction efficiencies of various solvents with varying geometries, molecular weights and saturated-unsaturated structures. Results of this work are being applied to the development of potential commercial processes.

Hydrocracking of Bitumens and Heavy Oils — The experimental pilot plant program for 1977/78 empha-

sized new feedstocks and additives for hydrocracking. Knowledge obtained with mined bitumen was applied to Lloydminster heavy oil and Lloydminster heavy oil residuum. As feed from the Imperial Oil in situ operation at Cold Lake became available it also was tested; these tests culminated in a co-operative 10-day test with the company.

The emphasis on heavy oil feeds was consistent with changing priorities in the branch. Earlier work on the development of proprietary catalysts and other additives was continued with the objective of coke-free operation at low pressures.

Cold Lake bitumen thermal hydrocracking was carried out at the maximum pitch conversion possible without reactor coking; an increase of 5°C in reactor temperature resulted in operating conditions indicative of coking. For Athabasca surface-mined bitumen at a given reactor temperature, the material topped to 800°F (427°C) gave higher pitch conversion and lower hydrogen consumption per pound of pitch converted (by about 30%), than the lighter feed topped to 500°F (260°C).

Catalytic hydrocracking studies have focussed primarily on two areas: catalyst preparation methods to extend catalyst life, and development of catalyst aging techniques. Of the catalysis research carried out under contract, one project warrants special attention. A consulting firm carried out a cost study for several different combinations of heavy oil and bitumen recovery and upgrading processes. Several petroleum companies have expressed considerable interest in the results. In some situations, hydrocracking compares favourably with coking processes.

One drawback to catalytic hydrocracking for bitumen and heavy oil upgrading is that the catalyst is quickly deactivated and its continual replacement is costly. Development of a cheap, throw-away catalyst that would perform effectively would thus contribute greatly to the feasibility of the process. One solid, which is plentiful in Canada and inexpensive relative to commercial catalysts, has shown potential both as a catalyst and as a "getter" to remove coke, organo-metallic compounds, and other undesirable products.

In other work, a carbon-based solid was shown to perform efficiently and economically as a catalyst support, forming the basis for a patent application. Fouling of the catalyst is permissible because it can be inexpensively replaced. Processing conditions can therefore be altered to allow greater fouling than with conventional catalysts. More specifically, reactor pressure can be decreased, thus reducing capital costs. The technique of using this material as a getter and catalyst has been an important element in discussions with process licensors on the transfer of Energy Research Laboratories (ERL) hydrocracking technology to industry.

As well, a study is underway to determine the parameters that control calalyst surface area, pore volume, and pore size distribution, and to determine optimum times and temperatures for catalyst dehydration and calcining.

Materials Research and Development — CANMET R & D on materials for oil sands and heavy oils processing has been directed towards three areas: (1) pressure vessel materials for thermal hydrocracking of bitumen and heavy oils, (2) corrosion and erosion resistant materials for pipelines for oil and slurries and (3) a process for producing abrasion resistant layers on steel castings to be used for such applications as digger teeth in mining tar sands.

The severe conditions of temperature and pressure and the composition of thermal hydrocracking environments in processes such as that developed within CANMET will require extensive utilization of austenitic stainless steels in exposed areas of the reactor. While these alloys are more resistant to embrittlement than ferrite steels, severe embrittlement can occur under certain conditions of temperature and cold work to which stainless steels are exposed. A research study has been undertaken to evaluate such effects on welded stainless steels under exposure to typical thermal hydrocracking environments.

Slurry pipelines for transporting oil sands are subjected to varying degrees of corrosion and wear of the line-pipe material. Research conducted within CANMET on four pipeline steels has suggested rationale for material selection as a function of abrasiveness of slurries.

Digger teeth used in the tar sands mining industry are customarily hard-faced after casting. CANMET has been reasonably successful in producing castings with an abrasion resistant carbide coating using a variation of the V-mould technique — a single-step process. While good results have been obtained for the coating of horizontal surfaces, the coating of vertical surfaces requires further improvement.

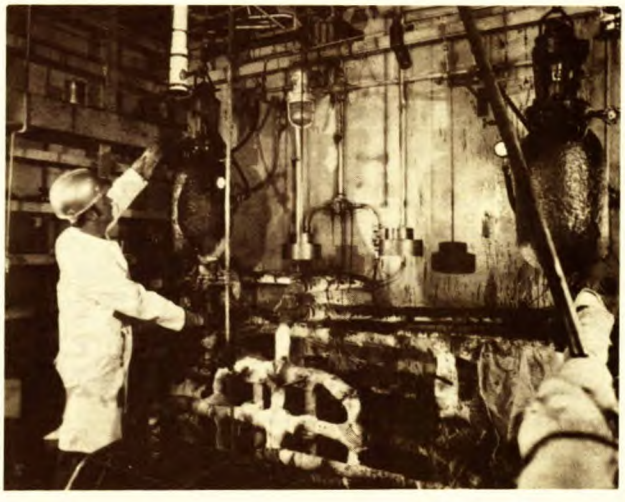


Fig. 8 - A portion of the one-barrel per day pilot plant for the hydrocracking process

Coal and Peat

Coal Mining Technology — It is anticipated that in the coming years, coal will play a major role in Canada as a substitute for oil and as a source of export income. This will mean further increases in coal production and consequently a need for more mines, both surface and underground. Much of CANMET's coal mining research is conducted in cooperation with the mine operators in actual mines rather than in the laboratory, and most of it is based at the Western Office in Calgary.

Ground Control — Predicting the behaviour of the strata above and around coal seams during mining is becoming increasingly important as underground coal production increases in volume, and deeper, more complex geological formations are exploited. CANMET has an extensive program of monitoring ground behaviour at several operating coal mines. The data produced will be used as input to ground behaviour models under development. Particular effort has been devoted this year to monitoring subsidence in the hydraulic mining operation of Kaiser Resources Ltd. in B.C., and to measuring roof behaviour and pillar stability.

Roof stabilization studies with bolts are underway at Canmore and McIntyre mines in Alberta. The behaviour of a new polyester resin grout roof bolt was successfully evaluated.

Mine Environment — Air quality in underground coal mining is significant in several respects. The presence of excessive concentrations of dust and noxious gases is a direct hazard to health. Methane, which is present to some extent in all coal workings, forms an explosive mixture with air when present in certain concentrations. Carbon monoxide (CO), apart from its direct health hazard, indicates possible spontaneous combustion of coal near the workings and consequent mining problems.

A trial CO monitoring system installed by CANMET at the Kaiser Resources hydraulic mine is functioning well and has identified sources of heat in the mine. Field and laboratory tests of an infrared detector were encouraging; this technique promises to augment CO monitoring as a method of locating spontaneous combustion.

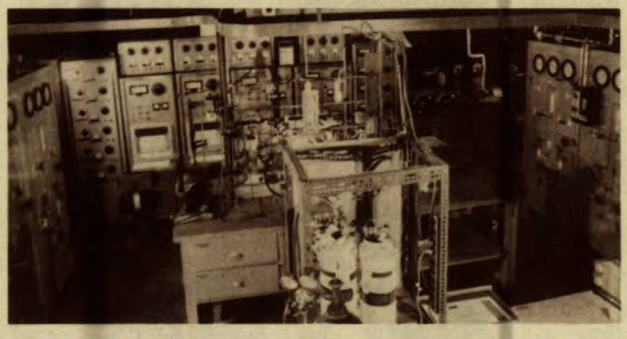


Fig. 9 - Catalysts play an important role in upgrading and refining petroleum feedstocks; this photograph shows bench-scale high-pressure hydrocracking facilities for evaluating catalysts for bitumen and heavy oil upgrading

Contracts to assess the value of methane drainage to reduce methane emissions in mines were completed. Results were presented to industry at a series of methane drainage seminars in British Columbia, Alberta and Nova Scotia. These seminars were well received and are expected to lead to actual methane drainage at appropriate mines, and possibly to commercial use of the recovered methane.

Equipment Safety — The possible presence in coal mines of methane and air in explosive proportions means that all possible sources of ignition must be suppressed. CANMET maintains the Canadian Explosive Atmospheres Laboratory (CEAL), part of whose function it is to certify equipment as suitable for use in coal mines. This work is carried out routinely on behalf of the provincial mining inspectors in whose jurisdiction equipment approval lies.

CEAL in 1977 also successfully carried out basic research, at the request of the International Electrotechnical Commission, on gas/air explosion pressures in flameproof enclosures at low ambient temperatures. The results, showing that pressures increase with decreasing temperature, have been recognized as a significant step in enhancing safety under relevant operating conditions.

Studies of methods of testing fire resistant hydraulic fluids have been carried out, and revealed problems in the methods. CEAL also prepared a first draft of the Canadian flameproof diesel code.

Coal Beneficiation — Many Canadian coals are difficult to beneficiate and some of these difficulties are uniquely Canadian. The conventional carboniferous coals of the Maritimes generally have a high content of finely disseminated sulphides and some have a high content of ash-forming minerals. The Prairie lignites are high in moisture and mineral content which necessitate specially-designed combustion equipment. The Hat Creek coal is especially high in clay minerals. The foothills and mountain coals are unusually friable and high in ash-forming constituents. Thus beneficiation is often crucial to the economic exploitation of coals and CANMET operates the only laboratory devoted to developing technology specifically adapted to Canadian coals.

CANMET's coal beneficiation efforts are conducted mainly at the Western Research Laboratory in Edmonton. Here, the 10-ton per hour pilot plant, based on the CANMET Automedium Cyclone (AMC), is used to characterize Canadian coals with respect to beneficiation; the plant was also used on a cost-recovery basis to develop coal beneficiation flow-sheets for commercial producers.

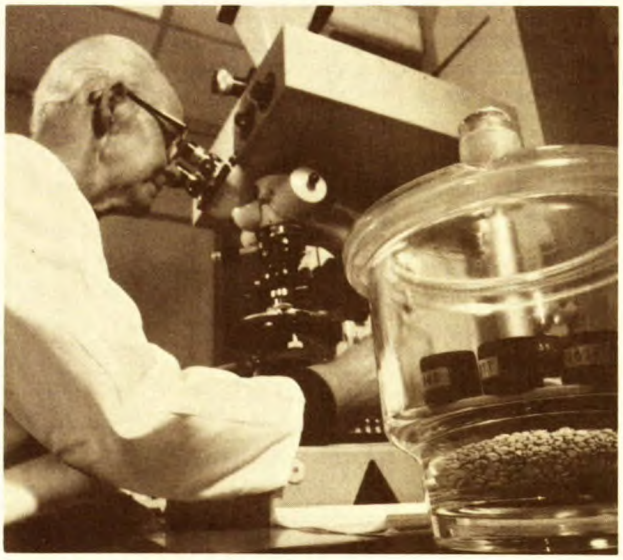


Fig. 10 - The microscope is an essential tool in evaluating coal and coke quality. Here a technician studies the petrography of pelletized samples from the carbonization pilot plant. In addition to providing a description of the constituents of the coal or coke, petrography can provide insight into the coking process

A mobile plant for demonstration treatment of coal washing water is currently being built. When complete, the plant will permit field appraisals of the CANMET process water recovery system to be made, and is expected to lead to adoption of the technology by industry.

Considerable work is in hand on selective flocculation to separate fine coal particles from suspension with clay or other constituents. This work has potential application both in beneficiating coal that requires fine grinding to liberate contaminants such as sulphur, and in cleaning process water to reduce pollution. This promises to be an area of significant benefit to the coal industry.

Of particular importance in 1977 was the extensive program by B.C. Hydro and CANMET to evaluate the beneficiation characteristics of Hat Creek coal. The Hat Creek deposit contains very large quantities of thermal coal which, however, will require a substantial degree of beneficiation before it can be burnt. CANMET's pilot plant was used to carry out a large number of analyses of the coal; these will be interpreted before a final technical report is produced.

Coke Production – Coke is the principal energy source for the blast furnace, the major source of new steel in Canada. Coke is the largest single cost item in steelmaking. Currently, about one quarter of the coal consumed in Canada goes to make coke. Coking coal is also a major export commodity, accounting for more than half a billion dollars in export revenue annually. In this context, improvements in the efficiency of coke manufacture (carbonization) and use could clearly be of significant economic benefit.

Applied research studies at CANMET on coal carbonization are formulated in cooperation with the Canadian Carbonization Research Association (CCRA) through regular meetings of the Association's Technical Committee. The Association represents coking coal producers, cokemakers and users. One of the priority projects sponsored by the CCRA includes self sufficiency in coals. Past studies have not emphasized the chemical characteristics of coals in relation to cokemaking. To augment the extensive coking trials using Canadian coals, the studies currently in progress will therefore also examine methods of improving the caking properties of the high-inert coals of Western Canada and explore the difficulties in the detection of oxidation of coals and its influence in the caking mechanism.

Studies are in progress on innovations in conventional cokemaking to broaden the scope of coals used and to increase coke strength. One such innovation is partial agglomeration of coke oven charges. Canada produces or has non-coking or poor coking coal that may be applicable to partial briquetting. Preliminary results from a major study on this subject indicate that coke quality increases when blends are partially briquetted, and that poor coking coals can be used in partially briquetted blends to produce metallurgical quality coke.

Canadian cokemakers presently import about 90% of their coking coals from the United States. The growing Western Canadian coking coal industry offers an alternative source of supply. A project is therefore underway to demonstrate: the feasibility of manufacturing blast furnace coke from Canadian coals – exclusively and partially; methods of accurately predicting coke quality from Canadian coals; and innovations to cokemaking to improve the quality of coke from Canadian coals. Coals from both Western and Eastern Canada were used. The data have been partly analyzed and reports are in preparation. Techncial-scale coke oven results indicate that it is possible to make a good quality metallurgical coke using commercial coking coals from Canadian sources.

The prime quality parameters of blast furnace coke are strength indexes based on the breakdown of the coke in a tumble drum. However, these indexes often do not correlate with blast furnace performance. Coke quality tests that more closely simulate blast furnace conditions would be a more accurate measure, and would lead to a better understanding of how to make cokes through techniques such as blending. One approach is to react coke with CO_2 at 1000-1100°C and study its rate of reaction or strength after reaction. Preliminary work has indicated that Western Canadian coals may be particularly good for cokemaking as their high temperature reactivities are among the lowest of all coals.

Investigation into the conversion of non-caking coals such as lignites, sub-bituminous and oxidized bituminous coals and anthracites into caking coals by thermal hydrogenation was also investigated. These non-caking coals generally do not pass through a plastic phase and consequently yield non-agglomerated chars. If thermally hydrogenated prior to carbonization, however, they produce agglomerated cokes on carbonization. Hydrogenation by use of a producer gas is being attempted as a means of reducing the expense associated with using pure hydrogen.

Coal Conversion — Coal is Canada's most plentiful fossil fuel. In addition to its value as a solid fuel for combustion and a raw material for metallurgical coke manufacture, it is a potentially rich source of liquid and gaseous fuels. As indigenous reserves of conventional oil and natural gas are depleted, coal is expected to play an increasingly important role in meeting the nation's fuel demands. Accordingly, CANMET has launched a research program to study the feasibility of extracting valuable liquid and gaseous products. Other feedstocks, such as pitch from the hydrocracking process, biomass and wastes are being considered as well.

The coal conversion program has two major components: contracts funded on a 50:50 basis with industry, and in-house research. Research agreement funding up to $20,000 is also available to Canadian universities, and a planned program to be implemented in 1978/79 will provide up to 100% funding for experimental projects to organizations unable to find 50% of the project costs. Fiscal year 1977/78 was the second year of the coal conversion program. Contracts completed or under way during the first two years included:

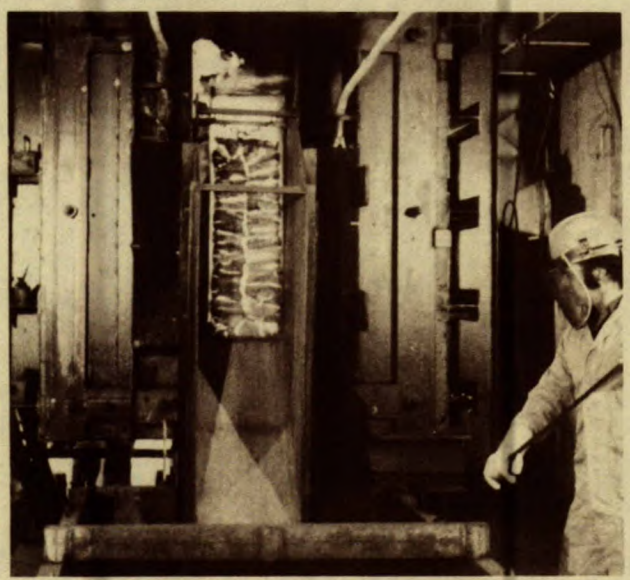


Fig. 11 - Coke ready for pushing from an experimental coke oven, in which the coking characteristics of coals and coal blends are evaluated; at its laboratories in Bells Corners and Edmonton, CANMET operates the only technical-scale coke ovens in Canada

ALCAN: Petroleum coke — Supply, demand, cost 1975-1990, and technical and economic appraisal of pure electrode coke by solvent refining of Canadian coals.

ALGAS Resources Ltd., Manalta Coal Ltd., and Shawinigan Engineering Co. Ltd.: Coal conversion in Alberta.

B.C. Hydro and Power Authority: Study of fluidized combustion and gasification of coal demonstration plant.

B.C. Research Council: Gasification of refuse from coal clearing plants.

Beak Consultants Ltd.: Potential for liquefaction of low-rank coals as a future source of liquid fuels.

Manalta Coal Ltd.: Drying and briquetting of Estevan and Onakawana lignite.

New Brunswick Electric Power Commission: Coal/oil slurry firing system on a utility boiler.

Nova Scotia Research Foundation: Low severity coal hydrogenation studies and Extractive coking liquefaction processes.

Ontario Research Foundation: Impact of the partial substitution of methanol in industrial and automotive fuels.

Saskatchewan Power Corporation: Utilization of Shaunavon coal and Coronach coal gasification study.

Shell Canada Resources Ltd.: Feasibility study for production of intermediate Btu fuel gas.

Union Carbide Canada Ltd.: Utilization of carbon monoxide flue gases from metallurgical electric furnace operations.

In the in-house research program, much of the effort this year was devoted to monitoring and current awareness of coal conversion projects under way throughout the world. As described below, construction began on a coal conversion pilot plant at the Bells Corners site at Ottawa.

A highly automated, continuous liquefaction unit is being designed to test a variety of Canadian coals under different liquefaction schemes. Installation was about 10% complete at year end. The unit which will be operated at up to 4000 psi and 500°C, and a maximum slurry rate of about 800 g/h has built-in versatility to handle a wide variety of feedstocks under a full range of process conditions of practical interest.

A pilot-scale fixed-bed gasifier has been designed to operate at atmospheric pressure and maximum

temperature of 1200°C. The reactor tube can accept charges of up to 10 kg. A range of Canadian coals will be gasified under a variety of conditions to determine reaction rates, yield, and product quality. Installation was about 10% complete at year end.

Gasification parameters for Canadian coals will also be studied in a thermobalance reactor for which design is about 75% complete. This unit will operate at up to 2500 psi (15,000 kPa) and 1000°C, and will accept batches of coal up to 20 g.

A continuous gasifier is also being designed to operate under maximum conditions of 2500 psi (15,000 kPa) and 1000°C, treating up to 20 g/min of pitch or 150 g/min of coal. It will be used to gasify pitch, bitumen, oil and coal under a range of conditions in either the fixed, fluidized bed, or entrained bed mode.

Materials Research and Development — A survey of corrosion and erosion-corrosion problems in the processing of coal was undertaken by CANMET to identify existing problems, to make recommendations for methods of corrosion control and materials selection, and to initiate R & D where indicated. Currently under way is an assessment of identified problems, such as the high wear rate in cyclones, relative to existing state-of-the-art concerning corrosion and wear control in coal processing.

Nuclear Energy

Uranium Processing — Concern over the acid drainage and radionuclide dissolution problems associated with current uranium tailings disposal methods, as well as the lack of thorium production for the CANDU reactor in Canada has prompted investigation into new and improved methods for the extraction of uranium and thorium from their ores.

The conventional method of extracting uranium from ores involves leaching with sulphuric acid and discarding of tailings containing pyrite and radionuclides at surface disposal areas. Although this method of extracting uranium is economically acceptable, the tailings produced are considered environmentally unacceptable.

The Energy Research Program of CANMET has therefore adopted long term objectives of developing new processing technology for radioactive ores that will produce higher and more efficient recoveries of uranium, thorium and radium, and, at the same time of producing wastes for disposal that meet the criteria of low level concentrations of metals and salts as well as radionuclides. Work is continuing in the following project areas: conventional H_2SO_4 leaching of new ores, preconcentration of ores, chlorination-roast, chlorine leaching, HCl leaching, HNO_3 leaching, and continuous ion-exchange recovery of uranium and thorium.

Materials for Nuclear Energy — A research project undertaken in support of the Atomic Energy Control Board with cooperation from Atomic Energy of Canada Ltd., and Ontario Hydro, has been directed towards investigation of the effects of wet hydrogen sulphide on the integrity of steel plates used in the towers of heavy water plants. A laboratory test procedure has been developed to simulate the hydrogen uptake measured in tower steels under operating conditions.

Electricity

Materials for Electrical Storage and Conversion — In the generation and distribution of electrical energy, secondary batteries could be used to store high-density energy in off-peak periods and to supply the extra energy needs to meet peak demands. The sodium-sulphur battery has been identified as a prime candidate for this type of load-levelling application and also as a power source for electrically-powered vehicles. A limitation exists in the conductivity, durability and cost of the solid state electrolyte, sodium-doped β-, or β"- alumina. CANMET scientists, having successfully prepared homogeneous powders of both electrolytes, this year, achieved fabrication of the solid electrolytes to near-theoretical density by a hot-pressing technique. The mechanical and electrical properties will be evaluated in the coming year.

Work has continued in the production of potassium-magnesium-titanium oxide solid-state electrolytes by wet chemical processes. Electrical properties of calcium stabilized zirconia produced in forms suitable for components for fuel cells have been determined. Similar studies have been initiated for hollandites.

Fig. 12 - A typical piece of metallurgical coke from the CANMET oven

Fig. 13 - Welding tests being conducted at CANMET's Physical Metallurgy Research Laboratories on Arctic-grade line-pipe steel at sub-zero temperatures

Energy Transportation

Materials for Natural Gas Pipelines – The emphasis of CANMET R & D has been on the evaluation of candidate line-pipe steels proposed for use in the Alaska Highway gas pipeline project. The objective of this work is to acquire the technical knowledge which, through technology transfer to the steel manufacturers and pipeline companies, will ensure the integrity of structures and equipment required for this major Canadian development.

The pipeline design for this project will utilize advanced and still-developing technology. The requirement for structural integrity of the pipeline, especially in view of the fragility of the environment through which it will pass, thus necessitates a continuing R & D effort.

In its comprehensive evaluation of the latest technological advances in pipeline steels this year, CANMET has concentrated on the two major Canadian candidate steels for 56-in. diameter pipe. Work has been completed on the evaluation of homogeneity of chemical composition, microstructure, inclusion content, tensile and impact properties, welding and weldability. The initiation and propagation of cracks under corrosion-assisted fatigue cycling has been examined as has the initiation of defects due to corrosion mechanisms, sulphide stress cracking, and hydrogen induced cracking. A study of the effects of mechanical damage on resistance to failure under fatigue loading has been initiated to provide a rationale for inspection standards for mechanical damage. Fracture toughness testing has been oriented towards the meaning and limitations of the standard tests for toughness of line-pipe steel – the drop-weight tear test and the less reliable Charpy V-notch impact test. Microstructural variations in the heat-affected zone of welds and their relationship to mechanical properties in this location have also been studied.

Additional work within CANMET has continued in the further development of direct-quench steels having the required toughness for pipeline applications at a yield strength of 700 MPa (100 ksi) compared with that of 500 MPa (70 ksi) for line-pipe steels currently being considered for northern gas transmission systems. This study has been oriented towards optimization of the composition, evaluation of the weldability, heat-affected zone properties, and susceptibility to hydrogen embrittlement of the weldments.

One requirement, recently identified, is the need for a better knowledge of mill processing parameters to permit optimization of the quality and rate of production of high strength low alloy steel plate of a type proposed for construction of northern gas transmission pipelines. A study to satisfy this requirement was initiated, preliminary results being promising.

Liquid Natural Gas Pipelines – A study commissioned to determine the feasibility of transport of liquid natural gas (LNG) pipelines taking into account improvements in available materials and technology of pipeline construction has indicated that such a mode of transport of natural gas is uneconomical over a long distance. It has identified, however, a novel concept for LNG transport over short to intermediate distance with distinct economical advantages over conventional cryogenic technology. A study is now planned on the technical and engineering viability of an internally insulated LNG pipeline for transfer lines and intermediate distance lines to LNG storage.

MINERALS RESEARCH PROGRAM

The CANMET Minerals Research Program (MRP) was established in 1974. It is concerned with research and development of non-energy minerals and metals. This review has been prepared according to the program/activity structure adopted by the Department of Energy, Mines and Resources (EMR).

All of the work done in MRP contributes to the EMR Minerals Program which is one of four. It has five activity areas of which CANMET contributes to three. The elements of the program with which CANMET is involved are:

(i) MINERALS RESOURCE DETERMINATION ACTIVITY
  Sub-activity — Technical Evaluation
(ii) MINERAL TECHNOLOGY DEVELOPMENT ACTIVITY
  Sub-activities — Development and Mining
  — Processing
  — Utilization
  — Conservation
  — Environment, Health and Safety
  — Transportation
(iii) ADMINISTRATION OF THE CANADIAN EXPLOSIVES ACT ACTIVITY
  Sub-activity — Authorization and Testing

The accounts of the R & D done in the 1977/78 fiscal year either by CANMET staff or under contract to CANMET given in the following pages follow the above tabulation.

The objectives of the three main activities as defined by EMR are:

(a) To provide an adequate knowledge base of Canada's mineral resources for the development of policies and programs regarding the exploitation of those resources and to encourage and facilitate their orderly development.

(b) To ensure the availability to Canada of adequate technical capability for the supply, processing, and use of minerals.

(c) To administer the Canada Explosives Act in the interest of public safety.

More specific objectives for R & D efforts on behalf of the department's Minerals Program are given in the following accounts of work done in support of the sub-activities.

MINERAL RESOURCE DETERMINATION

The objective of the Mineral Resource Determination Activity is to provide an adequate knowledge base of Canada's mineral resources for the development of policies and programs for exploiting them and to encourage and facilitate their orderly development. CANMET is contributing to these objectives by providing necessary data to determine the economic recoverability of known mineral deposits based on present and future technology.

Technical Evaluation

The work in this sub-activity is concerned with determining the quantity, quality, and productibility of Canadian mineral reserves. In CANMET this is done by providing information and data on the mineralogy, mineability and processability of metallic and industrial mineral resources throughout Canada.

Platinum Group Minerals — Continuing work on the identification and characterization of platinum group minerals has resulted in generating new data on their properties and structures. These data will be applied to the development of processes for improving the economic recovery of these precious metals from their associated minerals.

Base Metal Sulphides — Mineralogical studies of the massive sulphide deposits in New Brunswick were undertaken to determine their mineralogical composition and to identify problems likely to be encountered in developing economic processes for recovering the metals from these complex deposits. Particular emphasis was placed on the distribution of silver and other valuable trace elements in these highly pyritic deposits.

Fig. 14 - Recovering ore economically from the mines of tomorrow will require better and more efficient machines and equipment; the AEC Super-Roc Miner shown in photograph was certified for use in Canadian underground mines by the Canadian Explosives Research Laboratory

An inter-branch cooperative study of Canadian reserves and additional resources of nickel, copper, zinc, lead, and molybdenum was completed and published in 1977. A similar report on iron ore reserves and resources has also been completed and should be published in 1978.

Industrial Minerals – Preparation of an inventory of domestic alumina resources, such as anorthosite, clays, coal rejects, fly ash, and nepheline syenite was continued during 1977, with extensive sampling, analysis, and literature studies being carried out on such resources in Saskatchewan, Ontario, British Columbia, Quebec, and Nova Scotia. These resources will also be evaluated as to their technical and economic viability of new technology for producing aluminum.

An evaluation of the ceramic potential of typical clays and shales from the Prairie and Maritime Provinces was completed, and a comprehensive index, in English and French, of the salient ceramic properties of several hundred deposits across Canada is being compiled.

An assessment of indigenous phosphate resources is being prepared from published information and from current work being conducted by the Geological Survey of Canada. A similar assessment of chromite resources in Canada was completed and included an evaluation of methods for producing a marketable chromium concentrate from the Bird River deposits in Manitoba.

MINERAL TECHNOLOGY DEVELOPMENT

This activity includes all the department's responsibilities for performing, funding, and coordinating mineral research and development in Canada as well as for acquiring foreign technology and transferring it to industry. CANMET is a major contributor because it represents the department's centre for research and development related to mining, mineral and metal processing, and mineral based materials.

Development and Mining

Work done in the Development and Mining Sub-Activity has as objective the generation and promotion of technology for increasing efficiencies in operating mines other than coal. The main investigations in 1977 were in-depth studies of open pit mining, improving efficiencies of pillar recovery and deep mining, and contributing to a study into the feasibility of storing nuclear waste underground.

Open Pit Mining – About 70% of the ore mined in Canada is produced by open pit mining. It accounts for almost all of the iron ore and asbestos as well as substantial proportions of lead, zinc, and copper ores. Slope angle is perhaps the most important design parameter in open pit mining because it determines the amount of waste rock to be removed along with the ore, which in turn establishes the cut-off grade and the economics of the operation. For a large, deep open pit, steepening the slope angle by only one degree could reduce the amount of waste rock excavated over the life of the mine by about 20 million tonnes and result in a saving of $10 million.

In 1972, CANMET initiated a five-year project with the goal of developing improved open pit mining procedures. The projects have been a cooperative venture between industry and federal government with much of the development work being done under

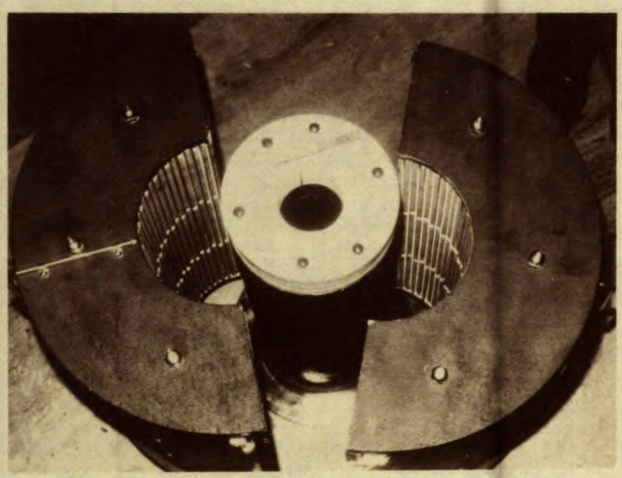


Fig. 15 - A high-temperature high-pressure triaxial cell developed for measuring rock stress in connection with the underground nuclear waste repository project

contract by Canadian mining companies, consulting engineers, and universities. The output is a comprehensive manual for use by mining engineers and is available now.

The manual is organized into ten main chapters and 16 supplements as follows:

1. Summary
An outline of the subject material in each chapter.

2. Structural Geology
Methods of gathering, storing, and interpreting geological data; dividing a pit into design sectors and assessing likely modes of failure for each; defining geological information required during the feasibility, planning and operating stages of mining; estimating costs of obtaining data. Five supplements to the chapter describe computer processing of geological data, geophysical site investigations, use of photogrammetry, and a geological case history.

3. Mechanical Properties
Planning a laboratory and field testing program describing methods of determining and analyzing the shear strength of discontinuities and rock substances; determining rock strength and physical properties; testing required during the feasibility, design, and operating stages. Five supplements to the chapter identify in detail sampling and specimen preparation and laboratory and field testing for design parameters.

4. Groundwater
Methods of measuring water pressure and permeability; construction and analysis of flow networks; methods of draining and monitoring; action required during feasibility, design, and operating stages; estimating costs; and conducting groundwater investigations. One supplement provides a user's manual on computer seepage analysis.

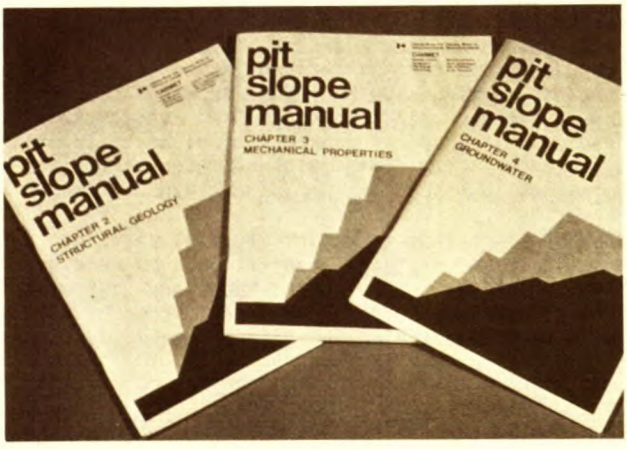


Fig. 16 - The Pit Slope Manual — a co-operative venture between government and industry, provides advice to improve mining procedures

Fig. 17 - Pre-splitting — drilling and blasting a line of holes around a pit perimeter is an effective means of controlling overbreak and provides smoother, safer walls

5. Design
Explanation of probability methods of analyzing slope stability; analysis of plane shear, rotational shear, and block flow modes of instability; financial analysis and economic risk of all factors affecting mining; design activities required during feasibility and planning stages; and estimating costs of design investigations. Three supplements are available on computer programs for plane shear and rotational shear analysis, and financial risk analysis.

6. Mechanical Support
Methods of support using rock anchors, shotcrete and buttresses, design of support systems; monitoring of anchor loads; cost estimates of support systems for bench support, moderate slopes and large slopes. One supplement is available on buttresses and retaining walls.

7. Perimeter Blasting
Effects on blasting of explosives, decoupling and decking, delays and spacing, collar and subgrade drilling, and site conditions; perimeter blasting techniques using buffer blasting, cushion blasting, pre-splitting, and line drilling; ground vibration, and damage levels; costs of perimeter blasting.

8. Monitoring
Description of optical and electro-optical surveying instruments to locate areas of potential instability; wire and rock bolt extensometers for detailed monitoring of unstable areas; methods of telemetry of data to a central location; and computer methods of data storage and analysis.

9. Waste Embankments
Site data required; design of embankments and modes of instability; construction of embankments; problems with permafrost.

10. Environmental Planning
Environmental management during exploration; eco-

logical, socio-economic and meteorological studies during planning stage; water pollution; reclamation with vegetation; federal and provincial legislation; estimated costs of ecological investigations; water and air sampling, and revegetation. A supplement is available on guidelines for reclamation by vegetation.

Well attended workshops were held in Winnipeg, Calgary and Montreal for the purpose of technology transfer. Audio visual slide casette packages have been prepared on all chapters. These will permit mine personnel to obtain a quick overview of the contents and relevance of individual chapters to local conditions.

Underground Mining – Although underground mining accounts for only 30% of the ore mined in Canada, it is important in the production of base metals – 92% of the nickel, 55% of the copper, 50% of the zinc, and 44% of the lead were produced from underground mines in 1975. CANMET has been involved in the ground control and safety aspects of underground mining for a number of years and present research is involved with problems which occur when converting from open pit to underground, and with mining methods utilizing backfill.

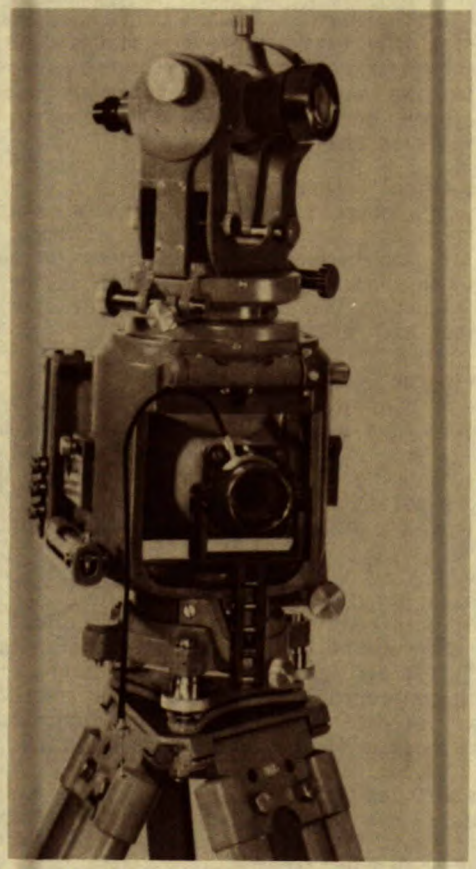


Fig. 18 - Wilde P30 photothiodolite used for terrestrial photogrammetry studies at the Elliot Lake Laboratory

A cooperative project with Texasgulf Canada Limited at the Kidd Creek mine has been underway since 1973. This mine started off as an open pit and then converted to underground without leaving a crown pillar separating the two operations. Any unexpected failure of the hanging-wall slope would be a hazard to the work force in the pit as well as disrupting operations in the underground mine. A remote laser monitoring system is used to measure the displacement of the hanging-wall in the pit as it is undercut during underground mining operations. Measurements taken during five years have indicated a cumulative relaxation of the pit wall into the pit of up to 7.3 cm (3 in.), but there has been no visible instability. The company has extended the monitoring system to the rest of the pit.

A program of stress determination has been completed at the Kidd Creek mine to determine the increase in pre-mining stresses with depth. Results agree with those obtained from other mines in Northern Ontario with the horizontal stresses being greater than the vertical stress. Two- and three-dimensional finite element model studies have been carried out for this pit to determine the re-distribution of stress due to underground mining and the resulting displacement. These studies were used to evaluate possible modes of failure for the hanging-wall slope.

Cut-and-fill is an important mining method in Canada and is used almost exclusively below 3000 ft (914 m) depth. It is also one of the most expensive and labour-intensive methods. Conventional cut-and-fill involves the repetitive alternate sequence of removing small slices of ore and back filling. A recent development in pillar recovery operations has been the blasting of large volumes of ore which in turn exposes a larger area of the fill wall in the adjacent backfilled stope. The stability of these unsupported fill walls is crucial to this mining technique.

A method using a modified finite difference numerical model has been used to determine the maximum free-standing height of backfill with varying cement contents and properties. Sampling procedures have been developed to obtain samples of cured backfill from filled stopes and results from strength testing have been used to model two mines under actual conditions. The validity of predictions based on numerical model analysis will be compared with field evidence which is expected to become available at the end of 1978.

Another important aspect of backfill pertains to its in situ drainage properties. Methods have been developed using both tube and twin rod permeameters based on electrical conductivity, which permit measuring in situ permeability without having to take samples.

Underground Nuclear Waste Repository – Concern has been expressed in Canada and other countries about management of radioactive waste from nuclear power stations. The major problem is the long life – in the thousands of years – of some radioactive sub-

stances. Storage in underground excavations a few thousand feet below surface has been proposed as one potential method of dealing with this problem.

CANMET, in conjunction with the Geological Survey of Canada and the Earth Physics Branch, is working with Atomic Energy Canada Limited on finding a suitable location in hard rock and designing an underground nuclear waste repository. CANMET's part of this study is to rank the potential repository sites on the basis of the mechanical and thermal properties of the rocks and to assist in the design of the repository by conducting in situ heater simulation tests. Methods for determining the thermal and mechanical rock properties have been formulated and the necessary testing equipment has been assembled.

For the in situ heater test, a special chamber has been excavated on the 2300 ft (701 m) level at the Creighton mine of Inco Metals Limited in the Sudbury area.

Rock samples were obtained for testing and in situ stress determinations carried out. Numerical model studies were done to determine the increase in temperature and thermal stresses in the rocks surrounding the heater and chamber.

Diamond Drilling — To support research and development in the diamond drilling industry, research contracts were funded for building and testing waterline heaters and data logging equipment.

Processing

Research in this sub-activity is done with a view to developing and promoting technology to increase recovery of marketable products from Canadian metallic and industrial mineral deposits and upgrading such products to higher value. This is effected by generating and promoting new and improved processing techniques, methods, and equipment, with due attention being paid to minimizing any possible adverse impact on public health and safety and on the natural environment.

Processing of Base Metal Sulphide Ores — Many producing mines treating complex fine-grained zinc-lead-copper-silver sulphide ores are presently recovering an average of only 65% of the metals contained in the ores. CANMET research is designed to develop processes to increase this recovery to at least 85% and to permit the exploitation of other known deposits dormant because of similar metallurgical problems. Ores of this type occur generally in New Brunswick but are not confined to the East — major orebodies are also known in Ontario and the Yukon. A conservative estimate, including the increase in recovery and production from dormant deposits, indicates that the success of this project could add $12 billion in metals recovered over the years to the Canadian economy.

CANMET research is based on the concept of producing a bulk concentrate at a minimum recovery of 90% of the contained metals at grades averaging at least 30% zinc, 10% lead, and 1% copper. Processes under investigation as a means of economically refining this concentrate to metal include a pressure-sulphuric acid-leach process, a sulphation-roast-leach process, a dry-way chlorination/oxidation process, and an atmospheric ferric ion leach process in chloride or sulphate media.

Development work on the pressure-sulphuric acid-leach process (PSA) was performed at Sherritt Gordon Mines Ltd. The work was financed by the Department of Regional Economic Expansion (DREE) through the federal/New Brunswick "General Development Agreement". EMR has representation on the management committee and CANMET is the scientific authority. Experimental work on this process was successfully completed during the year and a final report assessing its technical and economic feasibility is expected early in 1978.

Development work on the sulphation roast-leach process (SRL) was carried out at the New Brunswick Research and Productivity Council. This work was also financed through DREE with CANMET as scientific authority. Experimental work on this process progressed very well during the year, and a final report on its technical feasibility is expected by mid-1978.

Development work on the dry-way chlorination/oxidation and ferric ion leach processes is being carried out at CANMET, as is all of the comminution and beneficiation research required to produce the bulk concentrate feed for the four processes under investigation.

Fig. 19 - Section of test chamber being investigated for underground storage of nuclear waste

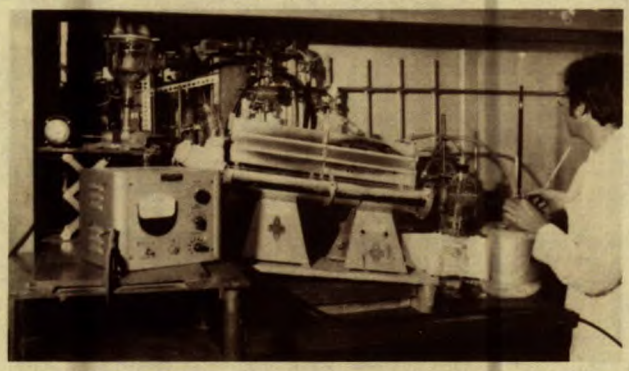


Fig. 20 - Dechlorination of ferric chloride for recovery of chlorine in the dry chlorination process

Comminution and Beneficiation of Base Metal Sulphides — During 1977, priority was given to comminution-classification research including a contract to Laval University, and to producing a bulk concentrate from the ore with and without a prior selective lead concentrate. In addition to laboratory batch and continuous grinding and hydrocyclone experiments, two sampling campaigns were conducted at operating mills — one at Heath Steele Mines Ltd. and a second at Brunswick Mining and Smelting Ltd. (BMS). Preliminary results indicated that the mathematical models chosen to simulate grinding and classification can validly be applied to these sulphide ores. This work is being carried out in cooperation with the Groupe de Recherche en Automatisation Appliquée à l'Industrie Minérale at Laval University.

Under the best conditions to date, a bulk concentrate grading 30% zinc was produced from BMS ore with recoveries of 95.3% zinc, 86.6% lead and 76.7% copper. Tests also indicated that a selective lead concentrate, grading 62.5% lead at 68% recovery could be produced prior to bulk flotation with no decrease in overall recovery of metal values.

Satisfactory progress was made during the year in the design and development of the continuous process development unit (CPDU). All the anticipated materials handling problems associated with the very small scale of operation were resolved and the fabrication, assembly, and installation of the flotation cells were completed. Installation of the INAX multi-stream XRF analyzer was also completed, and continuous on-stream trials are continuing.

To aid in the development of efficient grinding and beneficiation processes for treating complex sulphide ores, extensive mineralogical studies were carried out on BMS and Heath Steele ores and mill products. Image analyses were performed on a large number of samples to determine the percentages of free and locked grains, and the optimum grind required to ensure high recoveries of the desired minerals by flotation techniques. Other areas under investigation to improve efficiency or to reduce costs in the flotation process were "collectorless flotation" and new depressants for pyrite.

Dry Chlorination of Base Metal Sulphides — Development work on the dry-way chlorination/oxidation process continued during the year, with the fabrication, installation, and testing of a twin screw reactor, designed for continuous co-current chlorination of the bulk concentrate. Preliminary results indicate that solids mass transfer can be effected in the reactor at operating temperatures up to 350°C. Higher operating temperatures and lower chlorine stoichiometry to produce elemental sulphur instead of sulphur monochloride have still to be tested.

Tests using Fe_2O_3 diluent to improve flow properties and to control temperatures during chlorination of the bulk concentrate, indicate that Fe_2O_3 can be chlorinated in the presence of sulphur or sulphur monochloride even at relatively low temperatures. As this would be detrimental to the process, recycled liquid sulphur will be used in preference to solid oxide diluents to obtain temperature control during chlorination. New heat balances incorporating liquid sulphur coolant have been calculated.

Thermodynamic studies on sulphur monochloride decomposition were undertaken, and a CANMET contract with CIL to study S_2Cl_2 decomposition processes was completed.

Basic studies on the chlorination of sulphides were initiated during the year using differential thermal and thermogravimetric analytical techniques and microscopic and X-ray diffraction analyses to identify reaction products. The effect of particle size, inert diluents, temperature, and gas composition on reaction rates of individual and mixed sulphides is being investigated.

Corrosive wear tests on selected alloy materials were undertaken to determine their resistance to corrosion in a chlorine-sulphur atmosphere and their potential application as materials of construction for the dry-way chlorination/oxidation process.

Oxidation of the chlorinated product from the chlorination step can best be carried out in two stages. The first converts some of the iron chloride to Fe_2O_3 and drives off the remainder as gaseous ferric chloride. The second converts the gaseous $FeCl_3$ to Fe_2O_3 for recycling the chlorine.

Batch oxidation tests on chlorinated calcine indicate that soluble iron levels in the leach liquors from dissolution of the oxidized calcine can be as low as 0.002 g/l.

A fluid bed reactor was assembled and installed and testwork to evaluate a reactor concept for oxidation of $FeCl_3$ to Fe_2O_3 and chlorine was initiated. Considerable effort was expended to develop a method for feeding dry gaseous ferric chloride to the reactor.

A preliminary engineering and economic analysis of the dry-way chlorination/oxidation process was completed during 1977. The flowsheet analyzed included concentrate storage, drying, chlorination, oxidation, leaching, solids/liquid separation, lead chloride crystallization, and sulphur, chlorine, and waste heat recovery. Solution purification and metal recovery will be done as more data become available. The preliminary estimates indicate the process can be economically viable if the lowest retention times assumed in the chlorination and oxidation steps can be realized.

Leaching, Base Metal Sulphides — The second process under investigation at CANMET for the extraction of the metal values from Zn-Pb-Cu bulk concentrates is ferric ion leaching. Kinetic studies on the effect of acid concentration, sulphates, and alkali or alkaline earth chlorides on ferric chloride leaching of sphalerite and chalcopyrite were carried out. It was found that the presence of sulphate even in relatively low concentrations can adversely affect the dissolution rate of chalcopyrite. For sphalerite, direct acid attack occurs, yielding H_2S if the acid concentration in the ferric ion leach solution exceeds 1.0 molar.

Studies on the percolation leaching of BMS ore in ferric chloride media were completed and a final report is in preparation. Similar studies in ferric sulphate media are in progress, with initial results indicating a similar effect of acid concentration in ferric sulphate media as was observed in the chloride system.

A CANMET contract with Cominco for evaluating a selective ferric chloride leach process for recovering lead from a pyritic low-grade lead concentrate was completed. The work indicated that the process was technically feasible, but good economics would require a higher grade lead concentrate as feed.

A test program was initiated to determine the corrosion resistance of selected alloy materials in acid ferric ion environments, and to evaluate their potential application as materials of construction for a ferric ion leach process. A novel electrode assembly was developed which eliminated crevice corrosion of the test specimens and permitted the acquisition of reproducible results, based on potentiostatic polarization techniques.

Metal Recovery, Base Metal Sulphides — Regardless of the extraction process used to solubilize the desired metals, the resultant solutions must be purified to selectively recover the zinc, lead, and copper as high purity products. Investigation of solvent extraction techniques to separate copper and zinc in chloride media in the presence of small concentrations of iron, lead, and other minor impurities continued in 1977 with encouraging results. Also under investigation were processes — precipitation, ion exchange, carbon adsorption — for removing residual impurities from solvent extraction bleed streams, to facilitate recycling solutions to the process, and discharging bleed streams to tailings disposal.

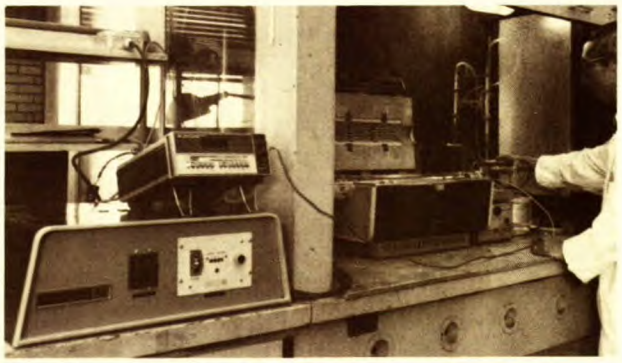


Fig. 21 - Apparatus for determining corrosion resistance of selected alloys in chlorine-sulphur atmospheres

The removal of iron from leach solutions is also of great concern, especially in the pressure sulphuric acid and sulphation roast leach processes, and in the conventional roast leach electrolysis process for zinc. Consequently, investigations were initiated to obtain basic data on factors affecting the precipitation of iron as jarosite, and to evaluate techniques to prevent the occlusion or co-precipitation of valuable components in the jarosite residues.

The recovery of lead and silver from solutions or leach residues is an important consideration in evaluating extraction processes for treating bulk concentrates. Solubility studies on silver chloride and sulphate in various chloride and sulphate media were undertaken to establish the likely distribution of silver in leach solutions and in residues from the extraction processes and to determine the conditions required to optimize lead and silver recovery.

Electrolysis is one of the better methods presently in commercial use for recovering metals from solution. CANMET research is aimed at developing electrowinning technology for recovering zinc, copper, lead, and silver from the chloride and sulphate leach solutions generated in the extraction processes under investigation. Current commercial practice in zinc hydrometallurgical plants has been reviewed with special emphasis on leaching, purification, and electrowinning procedures. Comprehensive studies have been undertaken in cooperation with Cominco and the University of Missouri to categorize solution impurity effects on zinc electrodeposition in sulphate media. These studies have shown excellent correlation between changes observed in zinc deposit morphology orientation and the zinc deposition overpotential that occur as a result of variations in the type and concentration of impurities, e.g., Sb, Co, Ge, and addition agents, e.g., glue in the electrolyte. During the past year these studies were continued to include the effects of lead and cadmium.

Also under investigation is the effect of entrained organics from solvent extraction purification on zinc, and on copper electrowinning in both

chloride and sulphate media. During the past year this work included the effects of D2EHPA, TBP, and Alamine, and the use of activated carbon for treating the electrolyte prior to electrolysis.

Experiments on zinc electrolysis in chloride media indicated that the addition of glue or Jaguar C-13 resulted in vastly improved zinc deposition. Work is continuing to determine maximum allowable limits of metallic impurities in the chloride electrolyte.

Processing of Ferrous Ores — Research oriented toward improving ferrous processing technology was limited during 1977 primarily to problems associated with the recycling of steel mill wastes. A literature search on methods used and an outline of the problems encountered in Canada for recycling of steel mill wastes was completed. Work on some aspects of waste oxide recycling, including the problem of zinc removal and recovery was undertaken and is continuing.

A very small effort on the use of zeta potential for characterizing bentonite as a binder for iron ore pelletizing was concluded.

Processing of Industrial Minerals — Based on an inventory of Canada's kaolinitic clays and an assessment of their characteristics, processing techniques are being developed to upgrade the most promising deposits, and to evaluate their potential for replacing imported materials presently used in the paper and ceramic industries. Samples from Saskatchewan, Manitoba, and Ontario were obtained and are being evaluated. A literature review on Canadian deposits of kaolinitic clays was completed.

An investigation designed to develop a process to improve the firing properties of high lime clays, and thereby extend their usefulness was unsuccessful and work in this area has been terminated.

Canada's aluminum industry, which in 1976 accounted for nearly $500 million in exports, is completely dependent on imported bauxite or alumina as the raw material. To guard against possible future supply problems due to political sanctions or unrealistic prices, CANMET is participating in a joint program with the U.S. Bureau of Mines to evaluate processes for producing alumina from domestic resources. Both acid and alkali leach processes are being investigated on various domestic sources of alumina, such as anorthosite, clays, coal rejects, and fly ash.

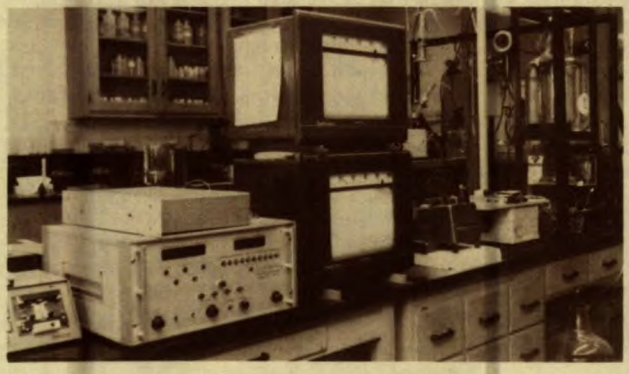


Fig. 22 - Apparatus for kinetic studies on ferric ion leaching

Acid extraction tests on Saskatchewan clay samples calcined at 750°C, indicated that 90 to 94% alumina extraction is possible under optimum conditions. Fluosilicic-assisted hydrochloric acid leach tests on anorthosite samples from the Lac St. Jean area indicated that extraction efficiencies of more than 90% can be achieved. The effects of leach time and temperature, acid strength and stoichiometry, and feed particle size and composition on alumina extraction were determined. Work on developing acceptable methods for recovering alumina from the acid leachates, recovering and recycling the acid, and controlling impurity build-up in the product and recycle streams is in progress.

Work was initiated during the year on a pressure caustic leach process for extracting alumina from Canadian anorthosite. Preliminary tests indicated a potential 90-95% alumina extraction at 240°C, with only a 15-min retention time. However, a high caustic ratio is required and difficulties have been encountered with silica removal.

The lime-sinter process was studied in detail on a laboratory scale on Canadian anorthosite from the Lac St. Jean region of Quebec, a U.S. anorthosite from Wyoming, fly ash from three coal-fired thermal plants — two in Alberta and one in Nova Scotia — and on a clay from southern Saskatchewan. Investigations were also conducted on synthetic mixtures to make controlled studies on the effects of changes in sinter composition. It was found that the degree of alumina extraction had a close relationship to the chemical composition of the material being treated. The anorthosites, which contain significant quantities of alkali oxides, give much better alumina recoveries than fly ashes, which in general are fairly low in sodium and potassium oxides. The critical requirement for the presence of some alkali oxide was confirmed in experiments with synthetic mixtures.

Efficient desilication of leach liquors from the lime-sinter or lime-soda sinter processes is a major requirement for producing alumina of acceptable purity (<0.05% Si). Consequently, investigations were conducted to determine the optimum temperature, retention time, and lixiviant composition to minimize silica dissolution during leaching of the sinters, while maintaining high alumina extractions. Tests were then conducted on the leach liquors to determine optimum conditions for desilication. It was found that alumina extraction increased and silica solubility decreased with increasing liquid/solid ratio and decreasing temperature and retention time. Atmospheric desilication, however, could not be achieved if sodium carbonate was used as the lixiviant.

Technical and economic evaluations of the lime-sinter and lime-soda sinter processes on Canadian anorthosites, including comparative material and energy requirements were completed. The results indicated that neither process could be competitive with the Bayer process using bauxite at present day bauxite prices, although the lime-sinter process could be competitive if adequate markets were available for the byproducts.

Material and energy balances for the acid extraction processes on anorthosite were completed and technical and economic evaluations are in progress.

Canada's imports of phosphate rock amounted to about $58 million in 1976. Most of this was used in fertilizers for domestic consumption. Canada possesses some phosphate rock deposits, but grades are generally considerably lower than those in the U.S.A. To determine the technical and economic feasibility of utilizing Canadian deposits, research is being carried out to develop techniques to recover the phosphate and associated byproducts such as uranium.

In 1977, flotation studies were conducted on stratabound shales from Fernie, B.C. to determine the feasibility of developing a method of upgrading the material. The studies involved investigation of several different flotation and desliming procedures, using various combinations of new reagents that have recently appeared on the market. Concentrates assaying more than 28% P_2O_5 with phosphate recoveries of 45% and tailings as low as 3.75% P_2O_5 were obtained.

Utilization

CANMET R & D on the utilization of mineral-based materials has as its general objective improved international competitiveness in selected downstream products that depend on the resource base and have significant value-added components. Projects are designed to develop new uses, improve behavioural characteristics, and increase quality of mineral-based materials. Consequently, the range of work including metal-forming technology, mitigation of corrosion and wear, durability of concrete, and certification of reference materials, gives the Utilization Sub-Activity considerable diversity. The focal point for this mineral-based materials technology development is the first priority in Canada's evolving mineral policies — "industrial development and diversification".

Materials for the Resource Industries — During the past year, research on materials for the resource industry was confined to investigating the role of corrosion and wear that occurs in ball and rod mills during the grinding of ores. The synergistic relationship that exists between corrosion and abrasion during comminution was studied using weight loss and grinding friction measurements. Various anions and cations in the slurry were shown to affect the abrasive interaction of steel balls at any given electrochemical potential and this phenomenon was used to explain variations in abrasive wear. In parallel studies, ferric ion was shown to be an effective corrosion inhibitor for martensitic stainless steel grinding balls in acid media with the critical concentration for inhibition being dependent on pH.

Integrity of Metallic Materials — The requirement for engineering information on the corrosion behaviour of structural alloys in the Canadian Arctic environment is being met by conducting an extensive systematic series of on-site corrosion tests. During this year, a new test method was perfected which is simple, small, and inexpensive — "the wire-on-bolt test". In this method, a length of clean, pre-weighed mild steel wire is wound onto the threads of a nylon bolt and the assembly is then exposed to the environment for one year. Arrangements were made to place the specimens at 50 Arctic sites and at an additional 10 southern sites. The resultant information will be used to characterize the extent to which engineering materials can be used in Arctic regions without loss of integrity through corrosion.

With a view to improving the performance, safety and reliability of welded structures, work was carried out on notch ductility and lamellar tearing of steels. In the first case, the

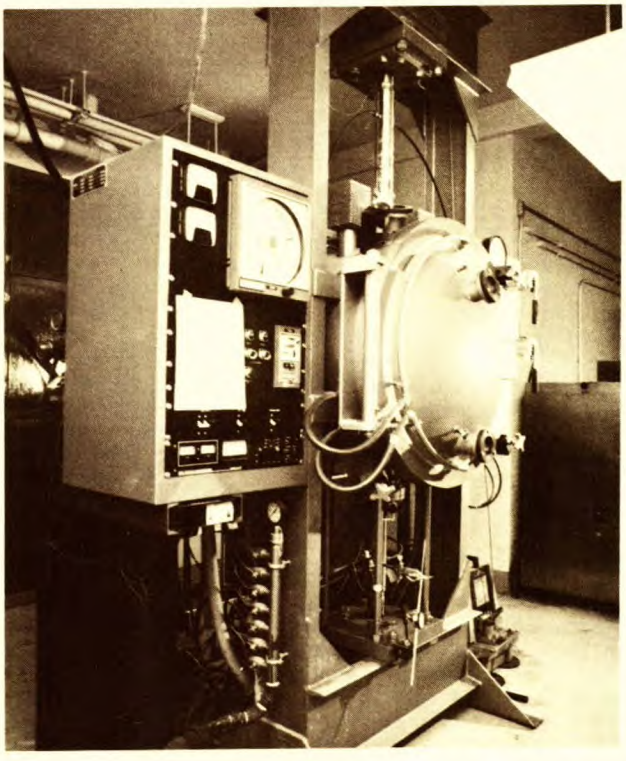


Fig. 23 - Hot press used to achieve high density ceramic compacts by simultaneous application of heat and pressure

Fig. 24 - Apparatus for measuring grinding friction between steel balls over the range of electrochemical potentials

objective was to develop a technical data base on notch toughness of welded joints in a "weathering" steel to be used by welding engineers for fabrication of structures subjected to the low temperatures prevalent in much of Canada. The second study was aimed at developing a simple test to assess the lamellar tearing behaviour of steels by the stud welding technique.

In cooperation with the Department of National Defence, extensive investigations were carried out on the integrity of HY 130 steel and high-strength cupro-nickel alloys for national defence applications. The work on HY 130 as a potential hydrofoil material was completed.

The objective of the fracture toughness and corrosion fatigue work on HY 130 has been to evaluate the fracture propagation properties of plate, welds, and heat-affected zones (HAZ), with and without stress relief and to determine corrosion fatigue crack growth rates in parent and weld metal as a function of environment, mean stress, and cyclic frequency. Crack growth rates in weldments were lower than those in parent plate at low mean stresses, but at the highest mean stresses used, the rates were significantly higher. These data, together with the thresholds for non-propagating cracks determined in this work, can be used as a basis for fatigue life estimates for HY 130 steel plate under a variety of environmental mechanical conditions. While the mean stresses which affect fatigue properties result from loading the structure and are therefore controllable, the residual stresses in weldments are not controllable.

The residual stress distribution over the HAZ and the weld in a circular patch test plate of HY 130 steel was measured by the strain gauge method and by the X-ray diffraction method using the dual detector stress diffractometer. By both methods, the tangential stress distribution showed high tensile peaks of the order of 552 MPa (80 ksi) at the two edges of the weld near the fusion zone on one side of the plate only. Normally, residual tangential stresses at weldments in steel plate would present no problem because a stress-relieving heat-treatment could be employed. However, HY 130 steel was found to suffer from temper-embrittlement and a substantial deterioration in impact properties under stress-relieving conditions. The high uncontrollable residual stresses were shown to be potentially dangerous because of the onset of environmental cracking in the form of radial cracks in the weld metal and HAZ when the plate is subjected to extreme hydrogen environments. As a result of this work, the limitations of HY 130 as a construction material for advanced marine vessels were defined.

To improve Canadian capability to supply appropriate high-strength copper alloy castings for shipboard sea-water piping systems, a study of the foundry characteristics, mechanical properties, and weldability of both the niobium-modified (ASTM B369) and chromium-modified (IN-768) 70/30 cupro-nickel alloys was undertaken. Because of higher strength and improved corrosion and erosion resistance, these alloys offer the advantage of a more compact piping system. The evaluation of their foundry practice and mechanical properties were completed and composition limits have been suggested to meet the specified mechanical properties.

Development of Industrial Mineral-Based Materials

— Energy and resource conservation through the development and use of less energy intensive materials of mineral origin are the objectives of the work on aggregates, cements and concretes. These materials are evaluated under exposure to normal and extreme temperatures and environments for use in frontier, off-shore, and nuclear construction by means of destructive and non-destructive testing methodology which in some cases is still in the development stage. The work also involves the development of mix proportioning methodology including mineral aggregates, fly ashes, and superplasticizers to produce extremely high-strength concretes and the determination of durability of these concretes under extreme temperatures. Specific examples are outlined below.

The second phase of the five-year project in cooperation with Hydro Quebec, Société d'énergie de Baie James, and Laboratoire de Béton consisted of preparing and curing a large number of concrete test specimens using Type II cement having a low tri-calcium aluminate content. These samples were placed by helicopter in a lake near the LG2 James Bay Project site where their durability in contact with northern acidic waters will be monitored, along with the concrete samples made

from Type I cement, and placed on test during Phase I of this project.

Because high-alumina cement could be a viable by-product of any large-scale production of alumina from anorthosite rocks, the degradation of high-alumina cement concrete is under investigation at CANMET. Phase changes involved in the hydration of high-alumina cement concrete have been monitored during storage periods of up to 6 months in dry air, moist air, and water at elevated temperatures and have been correlated with the mechanical properties of the concretes.

In studies on energy conservation, it has been shown that energy savings of from 5 to 50% can be obtained by the use of blended cements based on portland cement, fly ash, or granulated slags. Similarly, the use of light-weight aggregate produced from coal-mine shales has been under investigation as an energy conservation measure.

In addition to the extensive classical destructive testing which CANMET carries out on concrete, the need for non-destructive in situ testing has been recognized and pursued. Using in-house and contracted-out expertise, a simple bolt-pull non-destructive test is being developed which will facilitate determination of the physical properties of concrete as it exists at the present time in bridges, buildings, and other structures which were erected at some time in the past. Our present state of knowledge is limited to knowing the properties of the concrete 28 days after being poured.

Standards, Specifications, and Reference Materials — It is possible to go directly to the EMR publication "Mineral Policy Objectives for Canada" for the rationale of doing work in connection with standards, specifications, and reference materials. To contribute to the establishment of international specifications and standards for products in the mineral sector is one of the 12 strategy elements defined in the policy.

The work in this area is of two kinds: the first being concerned with specifications and standards for castings, especially non-ferrous castings, and the second with the provision of reference materials and the development of new and more accurate analytical methodology. Work of the second kind is embodied in the Canadian Certified Reference Materials Project (CCRMP) and activities related to participation in the committee structures of the International Standards Organization and the Canadian Standards Association.

Work on the effect of residual sand inclusions on the properties of cast magnesium alloys is aimed at developing both qualitative and quantitative standards for the users and producers of cast magnesium alloys containing zirconium. The latest results have shown that the yield strength increased slightly with increasing intensity of sand inclusions up to a certain maximum, then decreased. Ultimate tensile strength decreased gradually at the start, then decreased more rapidly giving approximately a 15% maximum decrease at the highest inclusion content. The elongation in less ductile alloys such as ZE41 and QE22 started to decrease rapidly at an intermediate inclusion content (Rating No. 4) and in the more ductile alloy ZE63 this occurred at a slightly higher inclusion content (Rating No. 5). Although unpublished as yet, the results have already been requested by two aircraft and helicopter producers to assist them in determining radiographic acceptance standards based on newly established ASTM reference radiographs developed earlier at CANMET.

The function of the CCRMP is to provide certified reference materials otherwise not available. These are used for quality control and calibration purposes in industrial, commercial, and government laboratories in Canada. While the emphasis in producing reference materials is on ores and related materials, some soils and metallic alloys as well are currently in various stages of certification. This fiscal year, an antimony ore, a blast furnace slag, and an iron ore were certified while the recommended values for reference ores MP-1 and KC-1 were updated because of changes from oxidation of sulphides in the ores. Four soils, a zinc concentrate, a lead concentrate, a copper concentrate and a high-grade uranium ore are being processed.

Work is also carried out on developing new analytical methods. Essentially the purpose is to maintain a level of analytical service commensurate

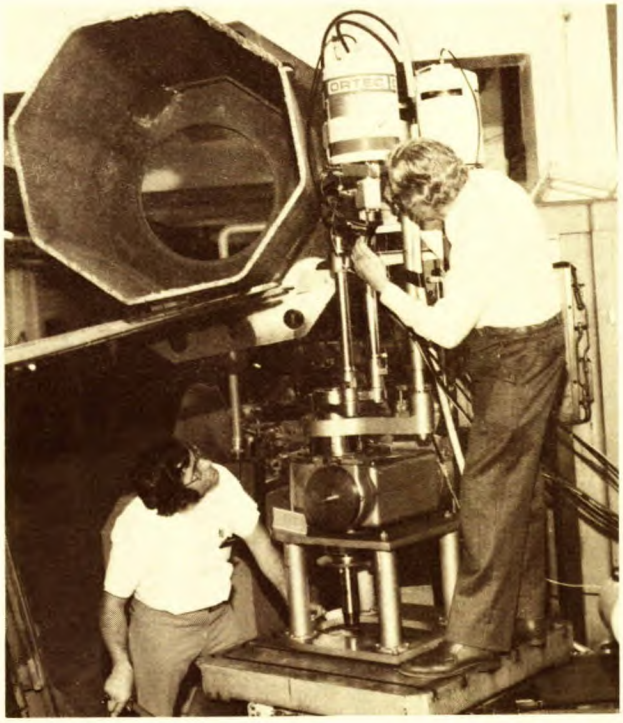


Fig. 25 - Dual detector stress diffractometer is used to measure residual stresses in metal structures

Fig. 26 - Compression test for concrete is continued to destruction of the sample to determine compressive strength

with the laboratory role as a national focus for mining and metallurgical research. One small example of this rather extensive project is related to atomic absorption methods. Tests were done on determining the precision and accuracy which could be obtained with atomic absorption spectrometry, in particular, by using angled-burner techniques for major constituent analyses on reference standards submitted for inter-laboratory comparison. The accuracy was found to compare very favourably with that obtained by classical analytical techniques.

Further Processing of Metals — Research to encourage further processing of metals is directly related to the government goal of emphasizing industrial development and diversification in implementing a mineral policy. The R & D is covered by five projects embracing work on moulding and casting technology, continuous casting, galvanizing, the forging of preforms made by powder metallurgy, and metal forming technology.

The developmental effort on the Vacuum Process (V-Process) has resulted in a patent application for the use of the process to improve the venting of mould cores during metal casting. Proper venting is required to ensure complete mould filling in complex thin-wall castings. Venting of the cores in the V-process moulds was achieved by breaking the thin plastic film in the core prints, thus permitting the low pressure in the sand to extract the core gases. An investigation of the feasibility of using this technique in the production of commercial magnesium castings of aircraft quality was contracted to industry. The initial phase of the work was so successful that it was immediately applied to the commercial production of castings which previously gave a high scrap rate.

There is considerable interest in the replacement of magnesium-bearing ferrosilicon with the more economical magnesium metal as the treatment alloy for producing ductile cast iron. As a ladle addition, pure magnesium creates a violent reaction with excessive glare and splashing and low recovery. The main thrust at CANMET has therefore been to introduce the metal in a controlled fashion. Injection of magnesium wire through a tuyere has been shown to be technically feasible with recoveries of 30 to 40% — comparable with ladle additions of magnesium-bearing ferrosilicon. The shroud gas used to keep the tuyere open has been shown to limit recovery but, as yet, methods of reducing the amount of shroud gas needed such as by nozzle design, porous plugs, and special injection devices have introduced other technical problems which have not yet been overcome.

Quick-setting binder systems for moulding sand are finding greater acceptance in the foundry industry. Organic binders were initially favoured as they were relatively easy to reclaim and possessed good shake-out characteristics. Their toxicity and contamination of the surface of the solidified castings have resulted in a trend towards inorganic binder systems. Unfortunately, these binders are not readily reclaimable and are difficult to shake out. Present work at CANMET has been directed towards developing an inorganic binder system based on magnesium oxychloride cement which would overcome these difficulties. When used with a suitable mould wash, a number of small steel castings were successfully made in-house and a 1000-lb casting was made by a Canadian foundry. The total sand losses in this system are minimal, being limited to the thin layer of sand adhering to the casting surface. In addition, it has been found that many of the other additives commonly employed in foundry operations — clay, cereals, iron oxide, etc. — were unnecessary.

A foundry method was developed to simplify production problems related to under-deoxidation (porous castings) and over-deoxidation (low conductivity) of copper alloys during melting. By first determining the oxygen content with a graphite rod, successful deoxidation was demonstrated with various combinations of phosphorus, lithium, boron, and magnesium. Oxygen can also be picked up very rapidly during casting and solidification, upsetting the oxygen-deoxidant balance achieved in the crucible, but this can be mitigated using a graphite-containing riser insulation. It is anticipated that commercial trials of this process will be conducted in a Canadian foundry next year.

A technique, using the CANMET developed closed-head continuous casting machine, has been developed to air-melt and continuously cast uranium bar. Although the cast bars displayed cold shuts on the surface and were cyclically distorted about the bar axis, it is anticipated the defects will be reduced or eliminated by mould design and extraction parameter modification. This technique will be used by industry to produce sufficient cast bar for user evaluation.

Work on galvanized structural steels was directed toward solving problems of galvanizing in association with welds in heavy-section structural steels. These problems may result from hydrogen

being introduced during processing or service, from cold work incurred during fabricating, and from residual stresses introduced during welding, which may contribute to hydrogen-induced cracking or liquid metal embrittlement. In addition, galvanizing research was continued with the objective of explaining and controlling the effect of silicon in promoting accelerated galvanizing activity on HSLA steels. In earlier work in this project a method was discovered for suppressing the "silicon effect" (vacuum-annealing pretreatment of the steels in the mill-finished condition caused the steels to galvanize exactly like plain carbon grades). However, the vacuum-annealing treatment has limited adaptability to commercial galvanizing operations, and the high annealing temperature required adversely affects the HSLA steel structure and properties. Therefore a less restrictive pretreatment procedure was sought. An extensive heat treatment program covering a wide range of time, temperature, and environmental conditions was applied to typical HSLA steels. Unfortunately, treatments, which successfully eliminated the "silicon effect" resulted in a degradation of mechanical properties.

Metal forming technology at CANMET in 1977/78 was focused on powder metallurgy forgings and superplasticity in Zn-Al alloys. In powder metallurgy, six different methods of preform forging iron powder were investigated for a Canadian-produced powder. It was found that the best procedure from the viewpoints of energy-saving and properties was simply to heat the preform to forging temperature and then forge, thus eliminating the sintering operation. The origin of voids in superplastic Zn-Al alloys was investigated. It was found that "as-received" there was no cavitation during superplastic deformation but certain heat treatments designed to increase the grain size induced susceptibility to the defect.

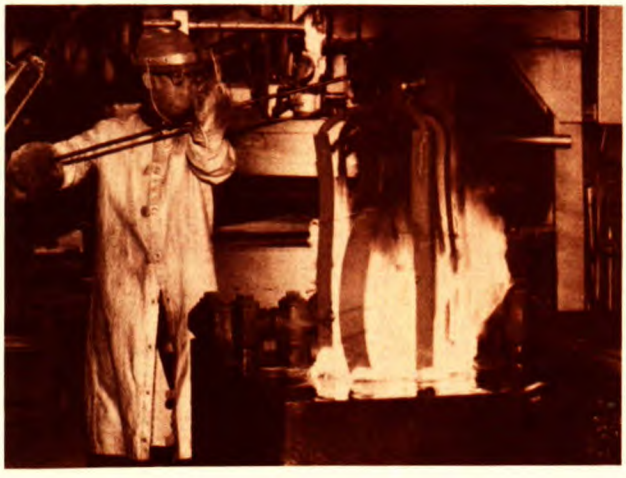


Fig. 27 - Heat treatment facilities at the Physical Metallurgy Research Laboratories are used to modify the properties of steel

Conservation

The need for conserving minerals and metals, and consequently energy, is self-evident. Conservation can be effected in the main by optimizing the use of metals in fabricated products, developing substitute materials, finding uses for what are now considered waste products, and increasing recycle ratios through technological innovation.

Mineral Wastes – In an effort to publicize the extent and availability of primary mining and mineral processing wastes in Canada and to stimulate interest in their utilization, data are being compiled on their occurrence, physical and chemical characteristics, and potential uses. In 1977, a CANMET report was published covering mining wastes in Quebec, and a similar report on mining wastes in British Columbia is nearing completion.

Research was carried out during the year to determine the technical and economic feasibility of producing an acceptable grade of gypsum from calcium sulphate wastes generated during the manufacture of titanium pigments and hydrofluoric acid.

An economic evaluation was carried out on a CANMET process for producing building brick from Hilton Iron mine tailings at Shawville, Quebec. The results indicate that production of building brick from mine tailings can be technically and economically viable.

Investigations were also carried out to determine if waste rock from Hilton Mines and from Marmoraton Iron Mines, Marmora, Ontario would be suitable for use as concrete aggregate, in view of developing aggregate shortages, particularly near large urban centres. From the results obtained both rock sources appear to be suitable; however, prolonged testing may be required to establish their long-term stability in concrete.

CANMET is also investigating processes for producing thermal insulating products from mineral waste materials. Foamed thermal insulation was successfully prepared from waste container glass, using both high-grade and waste limestone as a foaming agent. Compressing strength of the product was measured, and its thermal conductivity is being studied. Preliminary studies using mill tailings and waste glass with carbon as the foaming agent were also carried out.

A CANMET contract for a comprehensive review of mineral wool technology has been issued, and a bibliography of mineral wool literature is being prepared, in anticipation of an expanded research effort in this field.

Metallic Wastes – CANMET is investigating new sorting and refining techniques for separating and utilizing non-ferrous scrap from automobile shredding operations. A feasibility study was carried out on the use of X-ray fluorescence analysis as a means of identifying non-magnetic scrap. Both static and dynamic studies were undertaken. The

static study showed that a 1-sec integration time was sufficient to identify the material, and the dynamic study showed that the material could be identified while moving at speeds up to 20 ft/min.

Investigations were also carried out to determine the effect of impurities on the properties and uses of copper alloys, and thus determine if existing impurity specifications could be raised allowing increased recycling or less melt treatment of secondary copper. It was shown that for some alloys, present specification levels for antimony and iron could be increased significantly without affecting the physical properties of the alloys. Experimental work aimed at obtaining a better understanding of refining techniques for removing impurities from cast copper alloys was completed and a final report is in preparation.

Preliminary results on a process for recycling ferrous machining swarf into useful products without remelting have shown the process to be technically feasible, and excellent mechanical properties have been obtained in the final product.

Environment, Health and Safety

There has been increasing public concern in recent years regarding the impact on the surface environment by industries such as mining and pulp and paper, and by pipelines. Sulphur dioxide in stack gases, asbestos particulates, radioactive materials, and mercury and arsenic in watercourses are but some of the problems singled out as special causes for concern. Consequently, the development of technology aimed at reducing hazards to health, safety, and the natural environment due to mining and metallurgical operations has a high priority in the CANMET program.

Underground Environment — The objective of this work is to develop control methods capable of reducing levels of dust, radiation, various fumes, and noise in underground mines so that workers' average levels of exposure are significantly below provincial and federal standards.

The sampling and analysis of airborne dust in mines has been under investigation by CANMET staff for several years. A gravimetric sampling method in conjunction with X-ray diffraction for analyzing the quartz content of the sample has been developed and is being used in Canadian hard rock mines.

Quartz analysis of dust samples using infrared methods is also being assessed. The emphasis in research on airborne dust is changing from measurement and analysis to how dust is produced in various mining operations and how it can be suppressed.

CANMET and the U.S. Bureau of Mines are conducting a cooperative study of radiation problems related to uranium mining. An extensive system for continuously monitoring radon gas levels was installed at one mine to measure the radon levels produced by various mine operating functions. Preliminary results indicated that mucking operations are the major source of radon gas underground. Blasting produces a surge of radon gas but this is dissipated by the ventilation system between shifts. In another study, radon levels in stopes back filled with tailings were measured. The data obtained in these studies will be used to map out ventilation strategies to reduce radon concentration to safe levels.

Fig. 28 - Foamed glass insulation from waste material

A data bank on emissions from diesel engines used in mines is being developed so that ventilation requirements can be based on actual emission rather than simply on specifications for new engines. In 1977 tests were continued on worn, reconditioned, and new engines on the laboratory dynamometer. This work is being expanded through development of a portable device including a smokemeter for diesel particulates which will permit emission evaluation of partly worn engines to be made in the field. During 1977, contract research indicated that a catalytic purifier in series with a conventional waterscrubber could remove a substantial amount of toxic contaminants. It was also found that up to 99% of the particulate matter could be removed by dry filtration.

In 1977, a computer ventilation model for underground mines was developed and a contract was completed on the description of ventilation systems of Elliot Lake uranium mines. The model will be used initially to predict airflow distribution, then, at a later date to incorporate data on dust, radon gas, diesel emissions, and noxious fumes.

The attenuation characteristics of several types of ear muffs were evaluated in the laboratory and field tests on selected muffs are to follow. A noise dosimeter was built into a hard hat to improve field surveys of noise levels.

During 1977, CANMET initiated a number of contracts on health and safety aspects related to the uranium mining industry. A brief summary will serve to show the scope of these contracts.

The effect of a number of variables on the accuracy of dust sampling was determined:

1. Effect of air speed, direction, and sampler inlet velocity on quantity of dust collected by

Fig. 29 - Portable radon detector developed at CANMET

three types of samplers; effect of sampler location on the body; and effect of air speed on collection characteristics of three different cyclones.

2. An alpha dosimeter was assessed on the basis of calibration and measuring procedures and field trials in three mines.

3. The viability of continuously monitoring the underground environment was determined by acquiring and testing commercially available sensors; developing new measuring devices; field testing of sensors, and data transmission and computer systems. Sensors evaluated were anemometers, detectors and measuring devices for fire, radon gas and its daughters, carbon monoxide, methane, sulphur dioxide, hydrogen sulphide, oxides of nitrogen, oxygen, dust, temperatures, humidity, and barometric pressure.

4. A contractor produced a comprehensive report on research activities in health and safety aspects of uranium production; a sputum cytology study for the miners at Elliot Lake was initiated using funding by EMR, Rio Algom Ltd. and Denison Mines Ltd. The Elliot Lake Centre will continue to operate during 1978, but at a smaller level than originally anticipated.

5. Identification of main factors affecting pulmonary function and the respiratory diseases expected from long-term exposure to the underground environment were documented by reviewing medical evidence on inhalation of hydrocarbons including cigarettes and diesel exhaust and its effect on pulmonary disability.

6. A contract was completed to develop a prototype work suit to provide optimum conditions of water resistance and vapour permeability, and to design a helmet with integrated lamp, full face visor, filtered air system, and hearing protection including an improved battery to power the lamp and an air filter system.

Management of Tailings – For the last three years, CANMET has increased its research activities on uranium tailings, covering water contamination from radioactive materials as well as acidity caused by the oxidation of pyrite.

A five-year study on the physical and chemical properties of tailings, followed by vegetation growth tests in environmental chambers, and finally field trials, has resulted in a method of establishing a vegetative cover on uranium tailings at Elliot Lake. Initial treatment involves neutralizing the acidity and providing nutrients, followed by cultivation and seeding, then fertilizer applications over a five-year period, after which the vegetation is self-sustaining. A number of grass types can be used, but a mixture of Redtop and Creeping Red Fescue is recommended. Tests were also carried out with trees, and while some deciduous trees can readily be established, coniferous trees are not. Microbiological tests on the vegetated areas of the tailings indicated that sufficient numbers of micro-organisms exist to support a recycling process. A brief study was done on the uptake of radioisotopes by grasses. It was found that uranium, radium-226 and lead-210 contents were higher in the grasses than in a control soil. In 1978, a 40-acre tailings area was planned for vegetation.

A system of sampling wells and weirs has been established on an abandoned tailings area. Results indicated that most oxidation of pyrite, predominantly by bacterial action, occurs in the top 10 in. (25.4 cm) of the tailings. It was also found that the coarse tailings overlie highly acidic and radioactive water, whereas the water under the finer tailings is much less contaminated except for radium-226. Although this is considered the major source of radioactive contamination, a state-of-the-art report has been written dealing with the thorium aspects.

A preliminary study was done under contract on the stability of radium-barium sulphate sludges such as are deposited in settling lagoons after barium chloride treatment of effluents. In many respects, the results were inconclusive but did indicate that the sulphate concentration of the solution was the major factor affecting the release of radium.

In cooperation with Rio Algom Ltd., a five-year test program was started in 1975 to assess the effects of various surface treatments, including vegetation, on the quality of the seepage water. Tailings pits, 30 x 30 x 5 ft deep (9.1 x 9.1 x 1.5 m) were constructed. One pit was vegetated using the CANMET method; two other pits had surface coverings of 6 in. (15 cm) of barkfines and pit-run gravel respectively, another had 5 ft (1.5 m) of water; and one had no surface treatment

at all. The experiment will run for two more years to allow sufficient time for oxidation of the pyrite. Bi-weekly measurements are being taken of the contamination levels in the seepage water from each pit.

One method of avoiding the detrimental effect of pyrite oxidation in tailings is to remove the pyrite by flotation. Preliminary tests on old tailings indicate that up to 95% of the pyrite can be removed by flotation. Furthermore, preliminary results have indicated that a substantial concentration of radium-226 is recovered with the pyrite.

Waste Disposal — The formation of polythionates during grinding and flotation of sulphide ores results in a particularly troublesome environmental problem due to their tendency to slowly oxidize. This creates acid conditions in the receiving stream several miles downstream from the tailings pond. CANMET research is designed to establish the mechanism for thiosalt generation and to determine if conditions can be found to minimize it or to increase oxidation rates to allow neutralization of the acid formed before leaving the tailings pond.

The effect of pH, temperature, aeration rate, pulp density, mineral composition, and particle size on thiosalt formation was investigated during the year. Analytical methods were developed for determining both total thiosalts and individual polythionates. Sampling campaigns were conducted at Brunswick Mining and Smelting, Bathurst, N.B., and the distribution of thiosalts in the mill and the effect of individual milling operations — grinding, aeration, flotation, and SO_2 addition — was determined.

Fig. 30 - CANMET packed-bed filter installation on foundry cupola stack

A limited number of methods for thiosalt removal were briefly examined. These included ultraviolet induced oxidation, reverse osmosis, and bacterial oxidation. A preliminary report was also completed on the technical and economic feasibility of using a pipeline for discharging effluent to the ocean.

To contribute to the control of emissions from pyrometallurgical operations, CANMET has developed a packed-bed filter which is being evaluated on a pilot-plant scale for a number of applications requiring the efficient removal of particulates, the recuperation of waste heat, and the abatement of noxious fumes from gaseous effluent streams. During the past year, effort was directed primarily at technology transfer through continued assistance to both the Canadian and U.S.A. licensees on their joint design and installation of a commercial packed-bed filter at a foundry in Winnipeg. Numerous experiments were performed on the full-scale packed-bed module to verify new design features of the commercial unit. Field supervision during the final installation and commissioning was provided to ensure that critical process specifications were met. Problems with poor quality bed material and difficulties with bed removal were overcome through an extensive testing program and redesign of the bed removal system.

Plant Environment — To contribute to the solution of health and safety problems associated with asbestos fibre dusts generated during dry processing of asbestos ores, work is being carried out to develop the basic unit operations required for wet processing, and to evaluate these techniques on the basis of their technical and economic viability. Testwork on a demonstration-size cone type wet separator for primary separation of fibre was completed, and further testing to optimize working parameters is being undertaken.

Transportation

The general goals of CANMET R & D in the field of transportation is to develop and promote new and improved materials for Canadian commodity, public, and private transportation systems.

Materials for Transportation — Work on materials for transportation is focused on two areas. The object of work on the premium rail is to develop a fully weldable rail steel with superior wear properties while work on automotive materials is directed towards evaluating materials, particularly HSLA steels and aluminum alloys, suitable for the production of light-weight automobiles.

The premium rail project at CANMET has been pursued on three fronts: evaluation, development, and weldability. The objective of the first element has been to evaluate the hardness, strength, impact energy, fracture toughness, microstructure, and chemical composition of current commercial premium rail steels. Two heats of Cr-Mo steel, purchased by the Transportation Development Corp-

oration, were evaluated in detail prior to track testing at the A.A.R. facility. In addition, tests were completed on Cr, Mn-Nb-Cr, Mn-V, as-rolled carbon steel and quenched-and-tempered carbon steel rails.

In the development element, a study of accelerated cooling techniques was completed and an investigation of the effect of rolling temperatures on the fracture toughness anisotropy of carbon steels was finished and reported on. A study of the effect of rolling temperature parameters and various cooling rates on the texture of a low-carbon structural steel is virtually completed. An additional approach being taken to develop a Canadian premium rail is a steel based on the addition of vanadium and nitrogen to a standard rail steel. The material was processed at CANMET and a Canadian rail mill and is now to undergo metallurgical analysis and mechanical testing.

A weldability assessment schedule, capable of realistically evaluating potential welding problems in the new high-strength rail steels has been successfully developed. This is being used to assess the weldability of new steels being developed for use in high wear applications by the Canadian railways. The method is based on a simulation of the thermal cycle that the rail steel encounters during the flash-butt process used to weld the rails into long sections. Recommendations have been made for the welding of the latest experimental concast Cr-Mo rails produced by one of the Canadian rail producers.

To achieve better fuel economy, future automobiles will be constructed of lighter materials. Among other considerations, this means high-strength steels will be used in thinner gauges. It may also mean that aluminum will be used far more extensively in automobile construction. These possibilities pose a number of problems in steel forming and corrosion technology, as well as in the technology of producing suitable aluminum sheet by similar methods to those used for steel.

An inherent inverse relationship between strength and formability progressively limits the application of HSLA steels at high strength levels. Research into the optimization of processing parameters for HSLA steels in lighter-weight automobiles showed that the optimum properties are obtained by a relatively uncomplicated and economic 0.02% Nb steel. This optimization is achieved through manipulation of processing parameters and steel chemistry. It was shown that formability in hot-rolled grades varied as a function of strength, irrespective of composition. This research combined with work on aluminum alloys and plastics is aimed at assuring that the Canadian metal processing industry will be capable of supplying the new generation of materials for the automobiles of the 1980's.

Fig. 31 - Corrosion resistance of various metals is compared in an under-car test in Ottawa

Work on the thermomechanical processing of aluminum alloys is aimed at producing alloys with improved formability without decreasing the generally excellent salt corrosion resistance of aluminum alloys. A computer-based data acquisition system was installed and computer programs were written to acquire the thermomechanical test data and to calculate the requisite information. With this system which is now fully operational, testing speeds as high as 50 mm/min in the plastic part of the stress-strain curve can be used.

Work on the mitigation of automotive corrosion caused by road de-icers was undertaken in 1977 to provide expertise concerning the auto body corrosion problem, and particularly the intolerably high economic losses associated with the use of de-icing salts. Also, the development of new materials having potential uses in the automotive manufacturing industry was in progress at CANMET, and an evaluation of the corrosion characteristics of new materials was needed. Under-car corrosion tests were initiated to gain experience and to compare new automotive materials being studied with those in current use. At the same time, work on the development of a laboratory test is in progress to provide a rating technique that will simulate the under-car test method of rating. If successful, this technique will be used to study various alloys, media concentrations, temperature, and inhibitor effects, to define the operative corrosion mechanisms more clearly, and to propose improvements.

MINERAL AND ENERGY INFORMATION

One of the principal contributions of CANMET to the department's Minerals and Energy Programs is dissemination of information on advanced technology related to mineral and energy resources. Although by no means the sole source of relevant information, the Technology Information Division performs a vital linking role and attempts to further this branch objective by:

(a) editing and publishing the results of research and development activities of CANMET's own research scientists and disseminating it to industry, universities, and federal and provincial agencies, as well as abroad;

(b) providing scientific and technical information services, both domestic and foreign, to industrial, university, and government scientists throughout the country, including the branch's own staff of researchers as part of the national science-technology information dissemination network.

Technology information transfer activities of CANMET's research scientists are alluded to in other parts of this review in conjunction with the discussion of major research projects. This section provides a summary of major accomplishments and developments in the Technology Information Division.

Editorial, Publishing and Distribution Services

In any research and development organization one of the major means of technology transfer is the publication of the results of research performed in the laboratories and pilot plants. The Publications Section of the Technology Information Division is responsible for the editing and production of research reports of all types produced by CANMET scientists, assisted by expert technical editors, by readers, and by other support staff from the laboratories. Particular attention is paid to providing informative abstracts in the two official languages and arranging for full text translation where necessary. Responsibility for distributing senior branch reports is shared by appropriate agencies of Supply and Services, Canada and by CANMET's own Publications Sales Section; that for unclassified laboratory and other reports with limited distribution is arranged by the laboratories concerned and by the Technology Information Division.

Automated text processing equipment, first introduced last year, is now well entrenched and proving its value. Planning is underway to replace present equipment with more sophisticated but compatible new units capable of greater speed of operation and possessing additional desirable features.

In addition to the 770 new reports issued during the year, 107 previous confidential reports were declassified and released for public access.

The number of new reports produced decreased significantly from the previous year when it exceeded 900. It remains to be seen whether this reduction is an insignificant periodic variation, or represents a function of the gradually increasing time CANMET scientists devote to supervising CANMET-sponsored external contract projects.

Technology Information Dissemination

Documentation — In addition to disseminating the results of research produced by CANMET's own research scientists or performed on CANMET behalf by outside contractors, the Technology Information Division also has a significant role in technology transfer through a documentation and enquiry service.

Documentation of technical progress is carried out in the fields of mining technology and mineral processing. World literature of potential interest and applicability to the Canadian scene is systematically and regularly abstracted and incorporated into two computer-processable data bases. The mining technology data base grew by 2000 abstracts while 1100 new items were added to the mineral processing data base.

These two in-house produced data bases, along with commercially produced computer-based files, the expert knowledge of CANMET research scientists, and the extensive collections of the CANMET library are the primary resources used by information officers in responding to the many and varied requests for technical information from indus-

The number of reports produced in 1977/78 was 770 distributed as follows:

	MSL	ERL	MRL	PMRL	RPO	ADMIN	TID	TSD	TOTAL
CANMET reports	11	15	20	6	1	1			54
Presentations and journal submissions	54	32	18	22		2	2		130
Unclassified, limited external distribution	184	41	103	23	4		21		376
Unclassified, internal distribution	66	13	2	11	14		6	3	113
Confidential	25	23	3	45	1				97
Total	340	124	146	107	18	3	29	3	770

trial, government and university scientists, as well as the general public.

A small special data file on crushing and grinding was also initiated during the year. This file is intended to provide the basic material for a projected annual state-of-the-art review covering recent developments in this area of mineral processing.

A comprehensive library collection is another important resource, both for keeping CANMET scientists aware of developments in their respective specialties, as well as assisting in responding to the growing demand for technical information from outside the branch. By systematic monitoring and judicious selection of newly published works within CANMET's sphere of interests, (i.e., mining, process, extractive and physical metallurgy, and energy technology) 3111 new publications were added to the collection, over and above the more than 1600 periodical titles regularly received from around the world. At nearly 140,000 items consisting 80% of periodical and report literature and 20% monographic works, the collection is one of the most comprehensive of its type in Canada.

Fig. 32 - A two-unit word processing centre prepares CANMET Reports and other special publications, obviating the repeated retyping and proofreading necessary with conventional electric typewriters

Information Dissemination — Technology information dissemination activities are directed to two distinct publics: CANMET's own research scientists to keep them up-to-date on new developments and to answer specific enquiries relating to their various research projects, and to other government, industry, and university scientists and technologists whose current awareness needs are generally met by information resources at their home base, but who utilize CANMET expertise and information resources in seeking solutions to more complex scientific or technical problems.

The Technical Inquiries Section serviced on a bi-weekly or monthly basis a total of 68 current awareness profiles, mostly in metallurgy and mining technology. Profiles on metallurgical subjects are based on METADEX (the computer-based Metals Abstracts), those in mining technology on its own in-house created MINTEX (a computer-processable file of abstracts of mining technology). This current awareness service is provided in collaboration with the CAN/SDI network of the Canada Institute for Scientific and Technical Information of the National Research Council of Canada.

The Library responded to 51,384 requests from CANMET and other EMR staff, and sent 4736 packages of materials in response to requests from other libraries and individuals.

Enquiries requiring considerable depth of technical expertise and knowledge of many and varied information sources have continued to arrive in a

Inquiries Processed, 1977/78

Field of inquiry	Within Canada					Outside Canada				Totals
	CANMET	Other EMR	Other govt.	Educ. inst.	Industry	Other	Govt.	Educ. inst.	Industry	Other	
Mining	78	28	54	98	118	47	6	5	16	8	458
Min. proc. & ext. met.	120	4	73	23	75	23	4	3	12	2	339
Phys. met.	101	14	45	13	36	2	-	-	3	-	214
Energy	124	64	48	35	64	20	6	-	5	2	362
Totals	423	110	220	169	293	56	16	8	36	12	1373

steadily growing volume from all parts of the country. This attests to increasing awareness and appreciation by the external public of the division's excellent information resources and the dedication of the division's information officers to providing a complete and reliable technical information service.

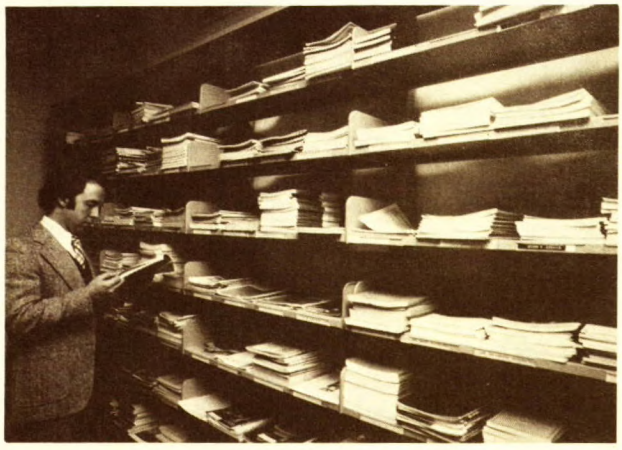


Fig. 33 - The CANMET Library, an important element in the Technology Information Division, subscribes to about 1600 serials, many of which are displayed in the reading room

A total of 1373 enquiries, usually requiring extensive search and consultation, were handled by the Technical Inquiries Section. A breakdown by principal subject of request and originating source is provided by the following table.

These figures represent only formal requests and exclude innumerable instances of advice, information or referral, provided by CANMET scientists and information officers in personal encounters or by telephone, which as a rule are not recorded.

International Cooperation in Information Transfer — The International Energy Agency (IEA) is one of several energy related organizations in which Canada is involved. CANMET's Technology Information Division, in cooperation with other EMR personnel, is responsible for information exchange between Canada and two coal-related projects of the IEA — the Technical Information Service and the Mining Technology Clearing House. Coal-related information originating in Canada is systematically supplied for input to IEA's coal information data file. Liaison with the Canadian coal industry, compilation of various coal mining data, and distribution of IEA coal-related information to appropriate agencies in Canada is also part of the division's responsibilities.

APPENDIX A

CANMET PROFESSIONAL STAFF

DIRECTOR-GENERAL'S OFFICE

D.F. Coates; B.Eng, M.Eng., Ph.D. (McGill), B.A., M.A. (Oxford); F.R.S.C.; Director-General
V.A. Haw; B.S., M.S. (Queen's); Deputy Director-General

RESEARCH PROGRAM OFFICE

W.A. Gow; B.A.Sc. (Toronto), P.Eng.; Director, Minerals Research Program (MRP)
D.A. Reeve; B.Sc., Ph.D. (Birmingham); Director, Energy Research Program (ERP)
L.L. Sirois; B.A., B.Eng., M.Eng. (McGill), P.Eng.; Activity Leader, (MRP)
D.G.F. Hedley; B.Sc., Ph.D. (Newcastle), P.Eng.; Activity Leader, (MRP)
D.W.G. White; M.Sc. D.Sc., (M.I.T.); Activity Leader, (MRP)
G.S. Bartlett; B.Sc., B.A. (Memorial); Economist
R. Sage; B.Sc. (Bristol), M.A.Sc. (Ottawa); Engineer
D.K. Faurschou; B.A.Sc. (Toronto); Activity Leader (ERP)
E. Smith; M.A., Ph.D. (Cambridge); Activity Leader, (ERP)

TECHNOLOGY INFORMATION DIVISION

J.E. Kanasy; B.Sc., B.A. (Windsor), M.A. (Michigan), Ph.D. (Pittsburgh); Chief of Division

LIBRARY

G Peckham; B.A., B.L.S. (McGill); Chief Librarian
J. Ho; B.A., B.L.S. (Ottawa); Librarian
A. Hobson; B.A., B.L.S. (Toronto); Librarian
K. Nagy; B.Sc., B.L.S. (McGill); Librarian

TECHNICAL INQUIRIES

A.S. Romaniuk*; B.Sc. (Queen's), P.Eng.; Phys. Sci.
G.M. Blondeau; B.A. (Queen's), M.A. (Guelph); Mining Abstractor
C.F. Dixon; B.Eng., (N.S.T.C.), P.Eng.; Phys. Sci.
A.L. Job; A.C.S.M. (Eng.), C.Eng.; Phys. Sci.
C. Lafkas**; B.Eng. (McGill), M.Sc. (Queen's); Phys. Sci.
B.E. Lawton; B.Sc. (Queen's), P.Eng.; Phys. Sci.
R.J.C. MacDonald; B.Sc. (St. Francis Xavier); Phys. Sci.
T.J. Patel; B.Sc. (Oregon State), M.Sc. (Washington State); Min. Proc. Abstractor
I. Slowikowski; M.A. (Ottawa), D.D.S. (Beirut); Slavic Lang. Spec.
G.W. Taylor; B.Sc. (Queen's); Phys. Sci.

PUBLICATIONS

C. Mamen; B.Eng. (McGill), Eng.; Phys. Sci.
L. Carreau; B.A. (Ottawa); French Tech. Sp.

TECHNICAL SERVICES DIVISION

E.K. Swimmings; B.Sc. (Queen's), P.Eng.; Chief of Division
D.M. Norman; M.I.Mech. Eng. Borough Polytechnique (U.K.); Engineer

ENERGY RESEARCH LABORATORIES

B.I. Parsons; B.Sc., Ph.D. (McGill), D.Phil. (Oxford); Chief of Laboratories

SYNTHETIC FUELS RESEARCH LABORATORY

J.M. Denis; B.A.Sc. (Ottawa), P.Eng.; A/Manager

BITUMEN PROCESSING

B.B. Pruden; B.Eng. (Sask.), M.A.Sc. (UBC), Ph.D. (McGill), P.Eng.; Res. Sci.
R. Ranganathan; B.E. (Annamalai, India), M.E. (Indian Inst. Sci.), Ph.D. (Sask.); Res. Sci.
R.B. Logie; B.Sc. (New Brunswick); Res. Sci.
C.P. Khulbe; B.Sc., M.Sc. (Agra, India), M.A. Sc., Ph.D. (Ottawa); Res. Sci.
D.J. Patmore; B.Sc. (Bristol), Ph.D. (Alberta); Res. Sci.

* Transferred 10/11/77

** Resigned 30/09/77

CATALYSIS RESEARCH

M. Ternan; B.A.Sc. (UBC), Ph.D. (McGill), P.Eng.; Res. Sci.
A.H. Hardin; B.Sc., Ph.D. (UBC); Res. Sci.
J.F. Kriz; Dipl. Eng., M.Eng. (Prague), Ph.D. (Dalhousie), P.Eng.; Res.Sci.
M.C.V. Sekhar; B.Sc. (Madras), M.Sc. (IIT, Madras), Ph.D. (Calgary); Phys. Sci.

COAL CONVERSION

M.M. Avedesian; B.Eng. (McGill), Ph.D. (Cambridge), P.Eng.; Res. Sci.
J.F. Kelly; B.Eng., Ph.D. (McGill), P.Eng.; Res. Sci.

RESEARCH ON BITUMINOUS SUBSTANCES

H. Sawatzky; B.S.A., M.S.A., Ph.D. (Toronto); Res. Sci.
A.E. George; B.Sc., M.Sc., Ph.D. (Cairo); Res. Sci.
S.M. Ahmed; B.Sc., M.Sc. (Osmania, India); Chemist

ANALYTICAL SECTION

E. Furimsky; Dipl. Eng. (Prague), Ph.D. (Ottawa); Chemist
D.M. Clugston; B.Sc., Ph.D. (McMaster); Chemist
A. Yates; B.Sc. (Manitoba); Chemist
R.E. Gill; B.Sc. (St. Francis Xavier); Chemist

CANADIAN COMBUSTION RESEARCH LABORATORY

G.K. Lee; B.Sc., M.Sc. (Queen's), P.Eng., C.Eng.,; A/Manager

HIGH-TEMPERATURE CHEMISTRY

T.D. Brown; B.Sc. (Durham), Ph.D. (Sheffield), C.Eng; Res. Sci.
T.J.R. Cyr; B.Sc., M.Sc., Ph.D. (UBC); Chemist

ENERGY CONSERVATION

A.C.S. Hayden; B.Eng., M.Eng. (Carleton), P.Eng.; Res. Sci.
R.W. Braaten; B.Eng. (Carleton), P.Eng.; Engineer

ENERGY SYSTEMS

F.D. Friedrich; B.Sc. (Sask.), M.Sc. (Queen's), P.Eng.; Res. Sci.
J.B.B. Aarts; B.Sc., M.Sc. (Eindhoven), Ph.D. (New Brunswick); Engineer

COMBUSTION TECHNOLOGY

COMBUSTION DYNAMICS AND AIR POLLUTION

H. Whaley; B.Sc., Ph.D. (Sheffield), P.Eng., C. Eng.; Res. Sci.

COMBUSTION ELECTRONICS

PILOT PLANT OPERATIONS

S.I. Steindl; Dipl. Eng. (Budapest), M.Sc. (Queen's), P.Eng.; Engineer
R.G. Fouhse; B.Sc. (Sask.), P.Eng.; Engineer

COAL RESOURCE AND PROCESSING LABORATORY

J.C. Botham; B.Sc. (Queen's), P.Eng.; Manager

ANALYTICAL AND EVALUATION SERVICES

Solid Fuels Analyses and Standardization

W.J. Montgomery; B.S.A. (Toronto); Phys. Sci.
J.Z. Skulski; Chem. Eng. (Wroclaw, Poland); Chemist
L.C.G. Janke; B.Sc. (Wilfrid Laurier), B.Ed. (Queen's); Phys. Sci.

Carbonization Operations

Coal Treatment

T.A. Lloyd; B.Sc. (Carleton); Phys. Sci.

Petrology

J.G. Jorgensen; B.Sc. (Carleton); Phys. Sci.

COAL AND PEAT RESOURCES

T.E. Tibbetts; B.Sc., B.Ed. (Dalhousie); Res. Sci.

Evaluation Laboratory

J.R. Donaldson, B.A. (Acadia); Phys. Sci.

Evaluation Laboratory (Sydney, N.S.)

M.E. Gillis; B.Sc. (St. Francis Xavier); Chemist

RESEARCH

B.J.P. Whalley; B.Sc., Ph.D. (McGill); Res. Sci.

Coal and Coke Constitution

B.N. Nandi; B.Sc., M.Sc. (Calcutta), Dr. Ing. (Karlsruhe); Res. Sci.
K. Belinko; B.Sc., Ph.D. (Carleton); Res. Sci.
L. Ciavaglia; B.Eng. (Carleton); Phys. Sci.

New Coking Technology

W.R. Leeder; B.Sc., Ph.D. (UBC); Res. Sci.
I.T. Lau; B.Sc., M.A.Sc. (Ottawa); Engineer

Metallurgical Processes

J.T. Price; B.Sc., M.Sc. (Calgary), Ph.D. (Western Ontario); Res. Sci.
J.F. Gransden; B.Sc. (London), A.R.S.M., Ph.D. (Western Ontario); Res. Sci.
K.S. Chao; B.A.Sc. (Cheng Kung), M.A.Sc. (Toronto); Engineer

WESTERN RESEARCH LABORATORY (EDMONTON)

J.L. Picard; B.Sc. (Alberta); A/Manager

COAL PREPARATION

M.W. Mikhail; B.Sc. (Assiut); M.Sc. (Alberta); P.Eng.; Engineer

CARBONIZATION

A.B. Fung; B.Sc. (Eng.) (Waterloo), P.Eng.; Engineer

FLOCCULATION RESEARCH

H.A. Hamza; B.Sc. (Cairo); Ph.D. (Newcastle-on-Tyne); Res. Sci.
N.E. Andersen; B.Sc. (Alberta); Phys. Sci.

PYROMETALLURGY RESEARCH LABORATORY

G.E. Viens*; B.A. (McMaster); Manager
R.A. Campbell; B.Sc., M.Sc. (Queen's); Res. Sci.
G.N. Banks; B.A. (UBC); Res. Sci.
G.V. Sirianni; B.Sc. (Ottawa); Res. Sci.
E.W. Montgomery**; B.Eng. (McGill), P.Eng.; Res. Sci.

ENGINEERING, DESIGN AND CONSTRUCTION SERVICES

R.E. Carson***; B.Sc. (Queen's); P.Eng.; Engineer
L.P. Mysak; B.A.Sc. (Ottawa); P.Eng.; Engineer

MINING RESEARCH LABORATORIES

T.S. Cochrane; B.A.Sc., M.Sc. (Washington); P.Eng.; Chief of Laboratories

ROCK MECHANICS LABORATORY

G.E. Larocque; B.Sc. (Carleton); Res. Sci. Manager
A. Boyer; B.Sc. (Montreal); Phys. Sci.
R. Boyle; B.Sc. (Ottawa); Comp. Sci.
A. Fustos; B.S.F./F.E., B.Sc. (UBC); P.Eng.; Engineer
L. Geller; Dipl. Mech. Eng. (Budapest); B.Sc. (Eng.) (London), M.A.Sc. (Toronto); Phys. Sci.
M. Gyenge; Dipl Eng. (Budapest), P.Eng.; Res. Sci.
A.S. Romaniuk; B.Sc. (Queen's); P.Eng.; Phys. Sci.
R.L. Sabourin; B.Sc., M.Eng. (Ecole Polytechnique), P.Eng.; Engineer
N.A. Toews; B.Sc. (Queen's); Res. Sci.
Y.S. Yu; B.Sc., M.Eng. (McGill); Res. Sci.
D.F. Walsh; B.Sc., (Memorial); Phys. Sci.
R.J.R. Welwood; B.Sc. (Queen's); Phys. Sci.
A.S. Wong; B.Sc. (National Taiwan University), M. Sc. (Ottawa); Phys. Sci.

ELLIOT LAKE LABORATORY

G. Zahary; B.Sc., M.Eng. (McGill); P.Eng.; Res. Manager
G. Allen; M.A.Sc., M.Eng. (South Dakota); Engineer
J. Bigu; M.Sc., (Barcelona), Ph.D.; Res. Sci.
K.C. Cheng; B.Sc., M.Eng. (Tainan Chen-Kung, Taiwan); Engineer
V. deKorompay; Dipl. Min. Eng. (Hungary); Phys. Sci.
M. Gangal; B.Sc. (Agra, India), M.Sc. (Rokee, India & McGill), Ph.D. (Calgary); Res. Sci.
D.G.F. Hedley; B.Sc., Ph.D. (Newcastle), P.Eng. Res. Sci.
G. Herget; Dipl. Geol., Ph.D. (Munich), P.Eng.; Res. Sci.
B. Kirk; B.Sc., (Waterloo); Phys. Sci.
G. Knight; B.Sc. (Birbeck, London); Res. Sci.
P.C. Miles; B.Sc. (Windsor); Engineer
B. Muir; B.Sc. (Queen's); Phys. Sci.
D.R. Murray; B.A.Sc. (McDonald College); Phys. Sci.
M. Savich; Dipl. Min. Eng. (Ljobljan, Yugoslavia), B.Eng., M.Eng. (McGill); Res. Sci.
R.O. Tervo; B.A.Sc. (Toronto), Ph.D. (Bradford), P.Eng.; Res. Sci.
N.K. Dave; B.Sc., M.Sc., (Rajastman, India), Ph.D. (Queen's); P.D.F.

CANADIAN EXPLOSIVES RESEARCH LABORATORY

J.A. Darling; B.A. (Queen's); Res. Manager
E. Contestabile; B.Sc. (Carleton); Phys. Sci.
K.K. Feng; B.Sc., M.Sc., Ph.D. (Iowa); Res. Sci.
R.R. Vandebeek; B.Sc., M.Sc. (Carleton); Chemist
C.A. Vary; B.Sc. (Ottawa); Tech. Off.
K. Hanasaki; B.Eng., M.Eng., Ph.D., (Kyoto, Japan); P.D.F.

WESTERN OFFICE, CALGARY

K. Barron; B.Sc., M.Sc., Ph.D. (London); Res. Sci., Manager
F. Grant; B.Sc. (Alberta), P.Eng.; Res. Sci., A/Manager
W. Baxter; B.Sc., (Calgary); Phys. Sci.
H.U. Bielenstein; B.Sc., M.Sc. (Alberta), Ph.D. (Queen's); Res. Sci.
R.N. Chakravorty; B.Che., (Jadavpur, India), Ph.D. (Nottingham); Res. Sci.
C.S.W. Chiang; B.Sc. (Alberta); Engineer
B. Das; B.ME (School of Mines, India), Ph.D. (Tech. Univ. of Mines, Czechoslovakia); Engineer
M.Y. Fisekci; Dipl. Eng., M.Eng., Ph.D. (Shefield); Res. Sci.
J.B. Livesey; B.Sc., Ph.D. (Cardiff); Res. Sci.
V. Srajer; M.A.Sc. (Mining) (Univ. of Applied Science, Czechoslovakia); Engineer

CANADIAN EXPLOSIVE ATMOSPHERES LABORATORY

J.A. Bossert; B.Sc., (Queen's); Res. Sci., Manager
E.D. Dainty; B.Sc., M.Sc., (Toronto) P.Eng.; Res. Sci.
G. Lobay; B.Sc., (Manitoba); Engineer
P. Mogan; B.A.Sc. (Toronto), P.Eng.; Res. Sci.
N. Sarin; Dipl. (Mech. & Auto Eng.) (Oxford College of Technology), B.A.Sc. Mech. Eng. (Waterloo); Engineer
S. Silver; B.Sc., (Manitoba); Res. Sci.
D.B. Stewart; B.Sc., M.Sc. (Queen's); Res. Sci.

---

* Retired 29/12/77
** Deceased 9/02/78
*** Retired 31/03/78

MINERAL SCIENCES LABORATORIES

R.L. Cunningham; B.Sc., M.Sc., Ph.D. (McGill); Chief of Laboratories
J.C. Ingles; B.A. (Western Ontario); Assistant Chief

CHEMICAL LABORATORY

R.G. Sabourin; B.Sc. (Ottawa); Manager
C.H. McMaster; B.Sc., M.Sc. (Queen's); Assistant Manager
G.H. Faye; B.A. (Saskatchewan); Assistant Manager

METALS AND ALLOYS

J.F. Fydell*; B.A.Sc. (Toronto); Chemist
E.H. MacEachern; B.Sc. (Mount Allison); Chemist
A.L. Letendre; B.Sc. (Sherbrooke); Chemist

ORES AND FIRE ASSAY

J.C. Hole; B.A. (Toronto); Chemist
R.R. Craig; B.Sc. (Glasgow); Chemist

SOLUTION CHEMISTRY

R.J. Guest; B.Sc. (Acadia); Res. Sci.
G.A. Hunt; B.Sc. (Carleton); Chemist
D.J. Barkley; B.Sc. (Carleton); Chemist
J.E. Atkinson; B.A. (Queen's); Chemist
A.D. King; B.Sc. (UBC); Chemist

SPECTROCHEMISTRY

G.L. Mason; A.Metallurgy (Sheffield); Chemist
J.L. Dalton; B.S., M.Eng. (Carleton); Chemist
C.W. Smith; M.Sc., Ph.D. (Queen's); Chemist
T.R. Churchill; B.Sc. (Western Ontario); Phys. Sci.
R.E. Horton; B.Sc. (Carleton); Chemist

SPECIAL ANALYSES

A. Hitchen; B.Sc. (McMaster); Chemist
B. Nebesar; M.Sc. (McGill); Res. Sci.
V.H. Rolko; B.Sc. (Manitoba); Chemist

SPECIAL PROJECTS

G.H. Faye; B.A. (Sask.); Res. Sci.
D.J. Charette; B.Sc. (Ottawa); Chemist
E.M. Donaldson; B.Sc. (Manitoba); Res. Sci.
E. Mark; B.A. (Toronto); Chemist
H.F. Steger; B.Sc., Ph.D. (McMaster); Res. Sci.

ORE PROCESSING LABORATORY

M.C. Campbell; B.Sc. (St. Francis Xavier, B.E. (N.S.T.C.), D.I.C., M.Sc. (London), P.Eng.; Manager
R.W. Bruce; B.Sc. (Queen's), P.Eng.; Assistant Manager

EXTRACTIVE METALLURGY

G.M. Ritcey; B.Sc. (Dalhousie); Res. Sci.
B.H. Lucas; B.Sc. (Queen's), P.Eng.; Res. Sci.
H.W. Parsons; B.Sc. (Alberta); Res. Sci.
V.M. McNamara; B.Sc., B.Eng., M.A.Sc. (Toronto), P.Eng.; Res. Sci.
A.J. Gilmore; B.Sc. (Manitoba); Res. Sci.
H.H. McCreedy; B.Sc., M.Sc. (Alberta), P.Eng.; Res. Sci.
J.M. Skeaff; B.A.Sc., M.A.Sc., Ph.D. (Toronto); Res. Sci.
N. St. Martin; B.A.Sc., M.A.Sc. (Ottawa); Phys. Sci.
A. Jongejan; Geol. Can. Drs. (Amsterdam), Ph.D.; Res. Sci.

MINERAL DRESSING

L.L. Sirois; B.A., B.Eng., M.Eng. (McGill), P.Eng.; Res. Sci.
A.I. Stemerowicz; B.Sc. (Queen's), P.Eng.; Res. Sci.
D. Raicevic; B.Sc. (Belgrade); Res. Sci.
G.I. Mathieu; B.A., B.Sc. (Laval); Res. Sci.
R.H. Yoon; M.Eng. (McGill); Res. Sci.
I.B. Klymowsky; M.Eng. (McGill), P.Eng.; Res. Sci.
W.H. Cameron; B.Sc., (Queen's); Phys. Sci.
G.A. Kent*; B.Sc., M.Sc. (McGill); Chemist

ENGINEERING AND ECONOMIC EVALUATION

E.G. Joe; B.Sc. (Queen's); Phys. Sci.
W.J.S. Craigen; B.Sc. (Queen's); Phys. Sci.
V.F. Harrison; B.Sc. (Queen's); Res. Sci.
F.J. Kelly; B.Ch.Eng. (N.S.); Res. Sci.

PHYSICAL SCIENCES LABORATORY

D.C. Harris; B.Sc., M.A., Ph.D. (Toronto); Manager

CRYSTAL STRUCTURE

J.T. Szymanski; B.Sc., Ph.D. (London); Res. Sci.
J.F. Rowland; B.Sc., M.Sc. (Queen's); Res. Sci.

SOLID STATE

M.G. Townsend; B.Sc., Ph.D. (Southampton); Res. Sci.

J.L. Horwood; B.A. (Toronto); Res. Sci.

CORROSION

G.R. Hoey; B.Sc., M.Sc., Ph.D. (Toronto); Res. Sci.
R.J. Brigham; B.Sc., M.Sc., Ph.D. (McMaster); Res. Sci.
A.W. Lui; B.Sc., M.A.Sc. (Windsor); Res. Sci.
J.C. Saiddington; Chem.Eng., M.A.Sc. (Toronto); Phys. Sci.

MINERALOGY

L.J. Cabri; B.Sc., M.Sc., Ph.D. (McGill); Res. Sci.
W. Petruk; B.Eng., M.Sc., Ph.D. (McGill); Res. Sci.
S. Kaiman; B.S., M.A. (Toronto); Phys. Sci.
M.R. Hughson; B.Sc. (Western Ontario); Phys. Sci.

* Retired 4/08/77

* Retired 10/06/77

J.L. Jambor; B.A., M.Sc. (UBC), Ph.D. (Carleton); Res. Sci.
T.T. Chen; B.Sc. (Taiwan), M.Sc. (Carleton), Ph.D. (Cornell); Res. Sci.

METALLURGICAL CHEMISTRY

J.E. Dutrizac; B.A.Sc., M.A.Sc., Ph.D. (Toronto); Res. Sci.
D.J. MacKinnon; B.Sc., M.A., Ph.D. (Ottawa); Res. Sci.
E. Rolia; B.A. (UBC); Chemist
D.J. Francis*; B.Sc., Ph.D. (Alberta); Res. Sci.
R.J.C. MacDonald; B.Sc. (St. Francis Xavier); Phys. Sci.
V.S. Sastri; B.Sc., M.A., Ph.D. (State U. of N.Y.); Chemist

PHYSICAL CHEMISTRY

A.H. Webster; B.A., M.A., Ph.D. (UBC); Res. Sci.
S.M. Ahmed; B.Sc., M.Sc., Ph.D. (Sask.); Res. Sci.
R. Sutarno; B.E., M.E., Ph.D. (N.S. Tech.); Res. Sci.
R.F. Pilgrim; B.Sc. (Queen's); Res. Sci.
L.G. Ripley; B.Sc., M.A. (Queen's); Res. Sci.
D.M. Farrell; B.Sc. (UBC); Chemist

INDUSTRIAL MINERALS LABORATORY

G.W. Riley; A.C.S.M. (Camborne School of Mines), P.Eng.; Manager

CONSTRUCTION MATERIALS

V.M. Malhotra; B.Sc., B.E. (W. Australia); Res. Sci.
H.S. Wilson; B.E. (Sask.); Res. Sci.
E.E. Berry; C.Chem., MRIC, Ph.D. (Surrey); Res. Sci.
G.G. Carette; B.Sc. (Laval); Engineer

NON-METALLIC AND WASTE MINERALS

R.K. Collings; Eng. Dipl., B.E. (N.S.T.C.), P.Eng.; Res. Sci.
A.A. Winer; B.A.Sc. (Toronto), P.Eng.; Res. Sci.
S.S. Wang; B.Sc. (Hong Kong Baptist), M.Sc. (U. of California), Ph.D. (Toronto); Phys. Sci.
C.A. Hamer; Dip. Eng. (Dalhousie), B.E. (Nova Scotia), M.Sc. (Queen's); Res. Sci.

ORE MINERALOGY

R.M. Buchanan; B.A., M.A. (Toronto); Phys. Sci.
J.A. Soles; B.A.Sc., M.A.Sc., Ph.D. (McGill), P. Eng.; Res. Sci.
R.S. Dean; B.Sc., M.Sc., Ph.D. (McGill), P.Eng.; Res. Sci.

CERAMICS

K.E. Bell; B.E. (Sask.), P.Eng.; Res. Sci.
T.A. Wheat; Ph.D. (Leeds); Res. Sci.
D.H.H. Quon; B.Sc. (National Sun Yat Sen U.), M.Sc. (Ohio U.), Ph.D. (Michigan U.); Res. Sci.
D.J. Green; B.Sc. (Liverpool), M.Sc., Ph.D (McMaster); Res. Sci.
V.V Mirkovich; Dipl. Eng. (Zagreb), Ph.D. (Toronto); Res. Sci.
T.B. Weston; B.A. (Toronto); Res. Sci.

* Resigned 31/10/77

PHYSICAL METALLURGY RESEARCH LABORATORIES

W.H. Erickson; B.Sc. (Mich. Tech.), Ph.D. (Durham), P.Eng.; Chief of Laboratories

METAL PROCESSING LABORATORY

M.J. Stewart; B.A.Sc., Ph.D., P.Eng.; Manager

FOUNDRY

R.K. Buhr; B.Eng. (McGill); Res. Sci.
C.J. Adams; B.Sc. (Sir George Williams), M.Sc. (Met.) (McGill); Res. Sci.
D.C. Briggs; B.Eng., M.Eng. (McGill), Ph.D. (Queen's); Res. Sci.
K.G. Davis; B.Sc., M.A.Sc., Ph.D. (UBC); Res. Sci.
B. Lagowski; B.Sc., M.Sc. (Polish Univ. London); Res. Sci.
R. Thomson; B.Sc., ARCST, Ph.D. (Glasgow); Res. Sci.
E.I. Szabo; M.Sc., Ph.D. (Nottingham); Res. Sci.
R.D. Warda; B.A.Sc. (UBC), Ph.D. (Cambridge); Res. Sci.

METAL FORMING

J.T. Jubb; B.A. Sc., M.A.Sc., Ph.D. (Toronto); Res. Sci.
A.F. Crawley; B.Sc., Ph.D. (Glasgow); Res. Sci.
W.A. Pollard; B.Sc., A.R.S.M. (London) P.Eng.; Res. Sci.
G.E. Ruddle; B.A.Sc., M.Sc. (Waterloo), D.Sc. (Virginia) P.Eng.; Res. Sci.
H.M. Skelly; B.Sc., Ph.D. (Glasgow), F.R.I.C., F.I.M.; Res. Sci.

NONDESTRUCTIVE TESTING

V.L. Caron; B.A.Sc. (Laval), M.Eng. (Paris); Phys. Sci.
J. Gordine; B.Sc., Ph.D. (Leeds); Res. Sci.

WELDING

K. Winterton; B.Sc., Ph.D. (Birmingham), P.Eng.; Res. Sci.
W.P. Campbell; B.Sc. (Queen's), P.Eng.; Res. Sci.
Z. Paley; B.Sc., M.Sc. (Haifa), Ph.D. (McGill); Res. Sci.

METAL DEVELOPMENT LABORATORY

D.W.G. White; S.M., Sc.D. (M.I.T.); Manager

CORROSION

G.J. Biefer; B.Sc., Ph.D. (McGill); Res. Sci.
J.B. Gilmour; B.Sc. (Queen's), Ph.D. (McMaster), P.Eng.; Res. Sci.
R.D. McDonald; B.Sc., (Queen's); Res. Sci.

ENGINEERING PHYSICS

A.J. Williams; B.Sc., M.Sc., Ph.D. (Birmingham), P.Eng.; Res. Sci.
D.M. Fegredo; B.Sc., M.Sc., Dipl., I.I.Sc., Ph.D. (Sheffield), A.I.M.; Res. Sci.
L.P. Trudeau; B.A.Sc., M.A. (Toronto); Res. Sci.
O. Vosikovsky; B.A.Sc., Ph.D. (Prague); Res. Sci.
K.C. Wang; B.A.Sc., Ph.D. (Rensselaer); Res. Sci.

FERROUS METALS

J.D. Boyd; B.A.Sc. (Toronto), Ph.D. (Cambridge); Res. Sci.
D.R. Bell; B.Eng. (McGill); Res. Sci.
M.J. Godden; B.Met., Ph.D. (Sheffield); Res. Sci.
R.F. Knight; B.Sc., M.Sc. (Queen's); Res. Sci.
M.J. Lavigne; B.A., B.A.Sc., Ph.D. (Laval); Res. Sci.
D.E. Parsons; B.A.Sc. (Toronto); Res. Sci.
W.R. Tyson; B.A.Sc. (Toronto), Ph.D. (Cambridge); Res. Sci.

METAL PHYSICS

W.N. Roberts; M.A., Ph.D. (Leeds); Res. Sci.
E.J. Cousineau; B.Sc. (Carleton); Phys. Sci.
E.E. Laufer; B.Sc., M.Sc. (Dalhousie), Ph.D. (Virginia); Res. Sci.
K.S. Milliken; B.Sc. (Queen's); Res. Sci.
C.M. Mitchell; B.A.Sc., M.A.Sc., Ph.D. (Toronto); Res. Sci.
J. Ng-Yelim; B.Sc. (Ottawa); Phys. Sci.
R.H. Packwood; B.Sc., Ph.D. (Birmingham); Res. Sci.

MECHANICAL TESTING

P.J. Todkill; B.A.Sc. (Toronto); Engineer
J. Harbec; B.Eng. (McGill), P.Eng.; Engineer

NON-FERROUS METALS

J.O. Edwards; B.Sc., M.Sc. (Manchester), P.Eng.; Res. Sci.
A. Couture; B.A., B.A.Sc. (Laval), P.Eng.; Res. Sci.
J.-L. Dion; B.A.Sc. (Montreal), P.Eng.; Engineer
M. Sahoo; B.Sc., B.E. (I.I.Sc., Bangalore), Ph.D. (UBC), P.Eng.; Phys. Sci.
L.V. Whiting; B.Sc., M.Sc., Ph.D. (McGill); Res. Sci.

CANMET STAFF AS OF MARCH 31, 1978

Division	Professionals	Non-professionals	Total
Administration and Central Services	4	94	98
Research Program Office	12	6	18
Energy Research Laboratories	54	72	126
Mining Research Laboratories	48	42	90
Mineral Sciences Laboratories	93	126	219
Physical Metallurgy Research Laboratories	49	82	131
Technology Information Division	11	20	31
Totals	271	442	713

APPENDIX B

CANMET REPRESENTATION ON TECHNICAL COMMITTEES 1977-78

INTERNATIONAL

BRITISH FLAME RESEARCH COMMITTEE (member) ..... G.K. Lee (ERL)

CANADA/SOVIET MIXED COMMISSION FOR COOPERATION IN THE INDUSTRIAL APPLICATION OF SCIENCE AND TECHNOLOGY
Non-Ferrous Metals Industry Working Group (chairman) ..... V.A. Haw (DGO)

EXTEST (regional representative) ..... J.A. Darling (MRL)

INSTITUTE OF BRIQUETTING AND AGGLOMERATION

Executive Committee (member) ..... T.E. Tibbetts (ERL)
Proceedings Committee (member) ..... T.E. Tibbetts (ERL)
Program and Papers Committee (member) ..... T.E. Tibbetts (ERL)

INSTITUTE OF MINES, YUGOSLAVIA

Sigurnost u Rudnicima (Safety in Mines)
Editorial Board (member) ..... M. Savich (MRL)

INTER-GOVERNMENTAL MARITIME CONSULTATIVE ORGANIZATION

Advisory Subcommittee to the Canadian delegate (member) ..... J.A. Darling (MRL)
Bulk Cargoes Committee (member) ..... H.F. Steger (MSL)

INTERNATIONAL ATOMIC ENERGY AGENCY

Advisory Group Division of Nuclear Safety and Environmental Protection (member) ..... M. Gyenge (MRL)
Tailings (consultant) ..... G. Zahary (MRL)

INTERNATIONAL COMMISSION ON ILLUMINATION

Canadian National Committee TC-4.1, Interior Lighting
Subcommittee on Mine Lighting (member) ..... A.L. Job (TID)

INTERNATIONAL COMMITTEE ON COAL PETROGRAPHY

Petrography (working member) ..... B.N. Nandi (ERL)
Petrography of Organic Sediments (member) ..... B.N. Nandi (ERL)
Subcommittee on Industrial Applications of Coal Petrology (member) ..... B.N. Nandi (ERL)

INTERNATIONAL COMMITTEE FOR SOLVENT EXTRACTION TECHNOLOGY

(member) ..... G.M. Ritcey (MSL)

AFFILIATION KEY:

DGO	Director-General's Office	MSL	Mineral Sciences Laboratories
ERL	Energy Research Laboratories	PMRL	Physical Metallurgy Research Laboratories
MRL	Mining Research Laboratories	RPO	Research Program Office
		TID	Technology Information Division

INTERNATIONAL CONFERENCE ON THERMAL CONDUCTIVITY (15th)

(chairman) ..... V.V. Mirkovich (MSL)

INTERNATIONAL ELECTROTECHNICAL COMMISSION

Technical Committee 31, Electrical Apparatus for Explosive Atmospheres
Canadian Subcommittee (chairman) ..... J.A. Bossert (MRL)
Subcommittee 31A, Flameproof Enclosures (chairman) ..... J.A. Bossert (MRL)

INTERNATIONAL FLAME RESEARCH FOUNDATION

Aerodynamics Panel (member) ..... H. Whaley (ERL)
Flame Chemistry Panel (member) ..... T.D. Brown (ERL)

INTERNATIONAL INSTITUTE OF WELDING

Commission IX, Behaviour of Metals Subjected to Welding
(chairman) ..... K. Winterton (PMRL)
(member) ..... W.P. Campbell (PMRL)
Subcommittee IX-F, Study of Recommendations Relating to Steels for Welding Construction (member) ..... L.P. Trudeau (PMRL)

INTERNATIONAL JOURNAL OF HYDROMETALLURGY (co-editor) ..... G.M. Ritcey (MSL)

INTERNATIONAL MINERAL PROCESSING CONGRESS

International Scientific Committee (member) ..... L.L. Sirois (RPO)

INTERNATIONAL MINERALOGICAL ASSOCIATION

Commission of New Minerals and Mineral Names
(Canadian representative) ..... D.C. Harris (MSL)
Commission of Ore Microscopy (Canadian representative) ..... L.J. Cabri (MSL)

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

Canadian Advisory Committee
CERTICO, Certification (member) ..... J.A. Bossert (MRL)
REMCO, Reference Materials (chairman) ..... R.L Cunningham (MSL)
(member) ..... G.H. Faye (MSL)
TC17/SC1, Analysis of Steel and Cast Iron (member) ..... R.G. Sabouin (MSL)
SC4, Heat Treated Alloy and Free-Cutting Steels (members) ..... R.K. Buhr (PMRL)
..... D.E. Parsons (PMRL)
SC4, Resulphurized Carbon and Alloy Steels (member) ..... D.E. Parsons (PMRL)
SC6, Methods of Mechanical Testing (chairman) ..... D.E. Parsons (PMRL)
TC82, Mining (chairman) ..... R. Welwood (MRL)
SC7, Test Methods other than Mechanical (member) ..... D.E. Parsons (PMRL)
SC11, Steel Castings (secretary) ..... D.E. Parsons (PMRL)
(member) ..... V. Caron (PMRL)
SC15, Rail Steels (member) ..... D.E. Parsons (PMRL)
TC18/SC1, Zinc and Zinc Alloys (member) ..... C.H. McMaster (MSL)
TC24, Sieves, Sieving and other Sizing Methods
(member) ..... G.W. Riley (MSL)
TC25, Cast Iron (member) ..... R.K. Buhr (PMRL)
TC26, Copper and Copper Alloys (chairman) ..... J.O. Edwards (PMRL)
SC1, Analysis of Copper and Copper Alloys (members) ..... C.H. McMaster (MSL)
..... R.G. Sabourin (MSL)
SC3, Cast Copper Alloys (member) ..... J.O. Edwards (PMRL)
WG5, Terminology ..... J.O. Edwards (PMRL)
TC27, Solid Mineral Fuels (chairman) ..... W.J. Montgomery (ERL)
SC2, Brown Coals & Lignites (member) ..... W.J. Montgomery (ERL)
SC3, Coke (member) ..... J.C. Botham (ERL)
WG9, Grindability (member) ..... W.J. Montgomery (ERL)
WG12, Plasticity (member) ..... J.C. Botham (ERL)
WG13, Ash Analysis (secretariat) ..... W.J. Montgomery (ERL)
TC33/WG3, Refractories (member) ..... K.E. Bell (MSL)

TC44, Welding (chairman) ..... K. Winterton (PMRL)
TC47, Chemistry (member) ..... C.H. McMaster (MSL)
TC56, Mica (chairman) ..... G.W. Riley (MSL)
TC58/SC3/WG7, Gas Cylinders Impact and Flattening
Test (member) ..... L.P. Trudeau (PMRL)
TC69, Application of Statistics (member) ..... R. Sutarno (MSL)
TC71, Concrete (chairman) ..... V.M. Malhotra (MSL)
TC77, Asbestos (member) ..... A.A. Winer (MSL)
TC79, Light Metals and their Alloys (member) ..... P.J. Todkill (PMRL)
SC1, Light Metals and their Alloys (member) ..... C.H. McMaster (MSL)
TC82, Mining (chairman) ..... R. Welwood (MRL)
(member) ..... A.L. Job (TID)
TC102, Iron Ores (secretary) ..... D.J. Charette (MSL)
(member) ..... R. Sutarno (MSL)
SC1, Sampling (chairman) ..... R. Sutarno (MSL)
SC2, Chemical Analysis (chairman) ..... D.J. Charette (MSL)
WG7, Statistics (chairman) ..... R. Sutarno (MSL)
SC3, Physical Testing of Iron Ores (chairman) ..... D.A. Reeve (RPO)
(member) ..... J.T. Price (ERL)
SC4, Size Determination, Iron Ores (chairman) ..... G.W. Riley (MSL)
TC111/SC1, Chain (member) ..... R.K. Buhr (PMRL)
SC4, Materials for Chain (chairman) ..... R.K. Buhr (PMRL)
TC119, Testing of Powder Metallurgical Materials and
Products (member) ..... H.M. Skelly (PMRL)
TC129/SC2, Aluminum Ores (member) ..... C.H. McMaster (MSL)
TC155, Nickel and Nickel Alloys (member) ..... M.J. Lavigne (PMRL)
SC3, Refined Nickel (members) ..... D.J. Charette (MSL)
..... C.H. McMaster (MSL)
TC156, Corrosion of Metals and Alloys (member) ..... G.J. Biefer (PMRL)
SC4, Methods of Analysis for Wrought and Cast
Nickel and Nickel Alloys (members) ..... C.H. McMaster (MSL)
..... D.J. Charette (MSL)
TC164, Mechanical Testing of Metals (chairman) ..... P.J. Todkill (PMRL)
(members) ..... J.T. Jubb (PMRL)
..... O. Vosikovsky (PMRL)
TC166, Ceramic Ware in Contact with Food (member)..... K.E. Bell (MSL)

INTERNATIONAL PEAT SOCIETY (vice-president) ..... T.E. Tibbetts (ERL)
Canadian National Committee (secretary-treasurer) ..... T.E. Tibbetts (ERL)

INTERNATIONAL SOCIETY FOR ROCK MECHANICS

(member of Council) ..... D.F. Coates (DGO)
Commission on Terminology, Symbols and
Graphic Representation (member) ..... W.M Gray (MRL)
Commission on Translations and Publications
(member) ..... G. Herget (MRL)
Commission on Standardization of Laboratory
and Field Tests (members) ..... M. Gyenge (MRL)
..... G. Herget (MRL)

INTERNATIONAL SOLVENT EXTRACTION CONFERENCE

Session on Uranium (chairman) ..... G.M. Ritcey (MSL)
(proceedings editor) ..... B.H. Lucas (MSL)

INTERNATIONAL STRATA CONTROL CONFERENCE (Sixth)

International Organizing Committee (chairman) ..... T.S. Cochrane (MRL)
(secretary) ..... T.E. Tibbetts (ERL)
Canadian Executive Committee (chairman) ..... T.S. Cochrane (MRL)
(secretary) ..... T.E. Tibbetts (ERL)
(members) ..... K. Barron (MRL)
..... A.S. Romaniuk (MRL)
Subcommittee on Papers (chairman) ..... K. Barron (MRL)

INTERNATIONAL THERMAL CONDUCTIVITY CONFERENCE (15th)

(chairman) ..... V.V. Mirkovich (MSL)

INTERNATIONAL TUNNELLING ASSOCIATION

Tunnelling Office of Canada (members) ..... L. Geller (MRL)
..... M. Gyenge (MRL)

ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT

Committee for Scientific and Technological Policy
Interdepartmental Committee (chairman) ..... V. Caron (PMRL)
International Group of Experts on Unstable
Substances (chairman) ..... J.A. Darling (MRL)
Ammonium Nitrate Subcommittee (member) ..... J.A. Darling (MRL)
Nuclear Energy Agency
Coordinating Group on Geologic Disposal
(member) ..... M. Gyenge (MRL)
Long-Range Transport of Air Pollution (member) ..... H.Whaley (ERL)
Waste-Heat Utilization (member) ..... F.D. Friedrich (ERL)

SOCIETY OF CHEMICAL INDUSTRY

Solvent Extraction/Ion Exchange Group (member) ..... G.M. Ritcey (MSL)

TRIPARTITE TECHNICAL COOPERATION PROGRAM
Sub-Group P, Technical Panel 1, Metals (member) ..... M.J. Stewart (PMRL)

WORLD MINING CONGRESS

Canadian National Committee(member) ..... D.F. Coates (DGO)
(alternate) ..... C. Mamen (TID)
Organizing Committee (member) ..... D.F. Coates (DGO)

UNITED STATES OF AMERICA

AMERICAN CONCRETE INSTITUTE

Chapter Activites Committee (chairman) ..... V.M. Malhotra (MSL)
Committee 214, Evaluation of Results of Strength
Test of Concrete (chairman) ..... V.M. Malhotra (MSL)
Committee 224, Cracking of Concrete (member) ..... V.M. Malhotra (MSL)

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS —

AMERICAN DEEP DRAWING RESEARCH GROUP (member) ..... J.T. Jubb (PMRL)

AMERICAN FOUNDRYMEN'S SOCIETY

Aluminum, Magnesium, and Reactive Metals Division
(member) ..... W.A. Pollard (PMRL)
Brass and Bronze Division (member) ..... J.O. Edwards (PMRL)
Ductile Iron Division Research Committee (member) ..... R.K. Buhr (PMRL)
Editorial Board, International Cast Metals
Journal (member) ..... R.K. Buhr (PMRL)
Sand and Expendable Mould Committee (member) ..... B. Lagowski (PMRL)

AMERICAN INDUSTRIAL HYGIENE ASSOCIATION (chairman) ..... G. Knight (MRL)

AMERICAN INSTITUTE OF MINING, METALLURGICAL
AND PETROLEUM ENGINEERS

Copper, Nickel and Precious Metals Committee
(member) ..... G.M. Ritcey (MSL)
Hydrometallurgy Committee (member) ..... G.M. Ritcey (MSL)

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Air Pollution Control Division Research Committee (member) ..... H. Whaley (ERL)
Fuels Division Research Committee (member) ..... G.K. Lee (ERL)
Research Committee on Corrosion and Deposits from Combustion Gases (member) ..... G.K. Lee (ERL)
Second International Symposium on Corrosion and Deposits from Combustion Gases Organizing Committee (members) ..... T.D. Brown (ERL)
..... G.K. Lee (ERL)
Task Force on Energy Conversion Research (member) ..... G.K. Lee (ERL)

AMERICAN SOCIETY FOR METALS

Advisory Technical Awareness Council (member) ..... J.D. Boyd (PMRL)
Council of the Materials Science Division (member) ..... J.D. Boyd (PMRL)
Metals Information Committee (chairman) ..... J.D. Boyd (PMRL)
Ottawa Valley Chapter (chairman) ..... M.J. Stewart (PMRL)
(secretary-treasurer) ..... G.E. Ruddle (PMRL)
(education chairman) ..... J. Gordine (PMRL)

AMERICAN SOCIETY FOR TESTING AND MATERIALS

Task Group on Mining Waste (chairman) ..... R.K. Collings (MSL)
Task Group on Naturally Occurring Inorganic Fibres (member) ..... A.A. Winer (MSL)
B-2, Non-Ferrous Metals and Alloys (member) ..... J.O. Edwards (PMRL)
B-5, Copper and Copper Alloys, Cast and Wrought (member) ..... J.O. Edwards (PMRL)
B-6, Die Cast Metals and Alloys (member) ..... J.O. Edwards (PMRL)
B-7, Light Metals and Alloys, Cast and Wrought (member) ..... J.O. Edwards (PMRL)
C-9, Concrete (member) ..... V.M. Malhotra (MSL)
C-9-02-05, Non-Destructive Testing of Concrete (members) ..... V.M. Malhotra (MSL)
..... A.A. Winer (MSL)
C-9-02-11, Accelerated Strength Testing (member) ..... V.M. Malhotra (MSL)
D-5, Coal and Coke (chairman) ..... W.J. Montgomery (ERL)
D-5-02, Nomenclature and Definitions (member) ..... W.J. Montgomery (ERL)
D-5-07, Physical Properties of Coal (member) ..... T.A. Lloyd (ERL)
D-5-15, Plasticity and Swelling (member) ..... J.C. Botham (ERL)
D-5-18, Classification (members) ..... B.N. Nandi (ERL)
..... J.G. Jorgensen (ERL)
D-5-21, Methods of Analysis (member) ..... W.J. Montgomery (ERL)
D-5-22, Physical Testing of Coke (member) ..... J.C. Botham (ERL)
D-5-27, American Group ISO/TC-27 (member) ..... W.J. Montgomery (ERL)
D-5-28, Petrographic Analysis of Coal (members) ..... B.N. Nandi (ERL)
..... J.G. Jorgensen (ERL)
D-5-29, Major and Trace Elements (member) ..... W.J. Montgomery (ERL)
D-30-03, High Modulus Fibres (member) ..... A.A. Winer (MSL)
E-2, Emission Spectroscopy (vice-chairman) ..... G.L. Mason (MSL)
E-2-11, Ores Slags and Miscellaneous Materials (chairman) ..... G.L. Mason (MSL)
E-7, Nondestructive Testing (member) ..... B. Lagowski (PMRL)
E-9, Fatigue (member) ..... O. Vosikovsky (PMRL)
E-16, Sampling and Analysis of Metal-Bearing Ores and Related Materials (member) ..... R. Sutarno (MSL)
E-28, Mechanical Testing (member) ..... P.J. Todkill (PMRL)
E-34, Toxic and Hazardous Materials (member) ..... A.A. Winer (MSL)
E-38-06, Materials of Construction from Recovered Materials (member) ..... R.K. Collings (MSL)
F-4, Surgical Implants (member) ..... W.N. Roberts (PMRL)

INSTRUMENT SOCIETY OF AMERICA

Committee SP-12, Instruments for Use in Hazardous Locations (member) ..... J.A. Bossert (MRL)
Subcommittee SP-12.13, Combustible Gas Detectors (member) ..... G. Lobay (MRL)

NATIONAL ASSOCIATION OF CORROSION ENGINEERS

Unit Committee on Inhibitors (member) ..... G.R. Hoey (MSL)
Unit Committee T-1F, Metallurgy of Oil Field Equipment (member) ..... I.C.G. Ogle (PMRL)
Task Group T-1F-1, Material Requirements: Sulphide Stress Cracking Resistant Metallic Materials for Oil Field Equipment (member) ..... I.C.G. Ogle (PMRL)
Task Group T-1F-15, Sulphide Stress Cracking Data by NACE Tensile Test Procedure (member) ..... I.C.G. Ogle (PMRL)

NATIONAL RESEARCH COUNCIL

Transportation Research Board
Committee A2-E03, Mechanical Properties of Concrete (chairman) ..... V.M. Malhotra (MSL)

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS
Fracture Committee ..... L.P. Trudeau (PMRL)

WELDING RESEARCH COUNCIL

High Alloys Committee (member) ..... M.J. Lavigne (PMRL)
Subcommittee on Corrosion Resistance (member) ..... M.J. Lavigne (PMRL)
Subcommittee on Heat Resistant Alloys (member) ..... M.J. Lavigne (PMRL)
Interpretive Reports Committee (chairman) ..... K. Winterton (PMRL)
Weldability Committee (member) ..... W.P. Campell (PMRL)

CANADA — FEDERAL

ATOMIC ENERGY CONTROL BOARD
Mine Safety Advisory Committee (members) ..... W.M. Gray (MRL)
..... D.G.F. Hedley (MRL)
(alternate) ..... G. Zahary (MRL)
Radioactive Waste Safety Advisory Committee (member) ..... D. Moffett (MRL)
Reactor Safety Advisory Committee (member) ..... L.P. Trudeau (PMRL)

CANADIAN GOVERNMENT SPECIFICATIONS BOARD

1-GP-3, Paints Aeronautical (member) ..... W. Dingley (MSL)
1-GP-6, Paints (member) ..... W. Dingley (MSL)
3-GP Petroleum ..... E. Furimsky (ERL)
8-GP, Sieves, Testing, Woven Wire (member) ..... G.W. Riley (MSL)
10-GP, Refractories (member) ..... K.E. Bell (MSL)
18-GP, Solid Fuels (members) ..... W.J. Montgomery (ERL)
..... T.E. Tibbetts (ERL)
31-GP-7, Conversion Coatings (member) ..... W. Dingley (MSL)
34-GP, Asbestos Cement (member) ..... A.A. Winer (MSL)
48-GP, Nondestructive Testing (member) ..... V. Caron (PMRL)
51-GP, Thermal Insulation (members) ..... A.A. Winer (MSL)
..... A.C.S. Hayden (ERL)
52-GP, Major Kitchen Equipment (member) ..... R.D. McDonald (PMRL)
53-GP, Shears (member) ..... D.E. Parsons (PMRL)
75-GP, Ceramic Tile (member) ..... K.E. Bell (MSL)
77-GP-1, Pipe Joints (member) ..... W. Dingley (MSL)

CANADIAN TRANSPORT COMMISSION

Cast Steel Propeller Specifications Committee (member)..... D.E. Parsons (PMRL)

CANMET

Editorial and Publications Committee (chairman) ..... C. Mamen (TID)
(members) ..... W. Gardiner (ERL)
..... A.L. Job (TID)
..... S. Kaiman (MSL)
..... G.W. Taylor (TID)
..... P.J. Todkill (PMRL)

COUNCIL OF FEDERAL LIBRARIES

Committee on Collections Rationalization ..... J.E. Kanasy (TID)
Subcommittee on Library Delivery Services ..... G.M. Peckham (TID)

DEPARTMENT OF ENERGY, MINES AND RESOURCES

Coal Committee (members) ..... J.S. Cochrane (MRL)
..... T.E. Tibbetts (ERL)
Subcommittee on Coal Reserve Assessment (member) ..... H.U. Bielenstein (MRL)
Coal Coordinating Committee (member) ..... D.A. Reeve (RPO)
Committee of Chief Librarians (member) ..... G.M. Peckham (TID)
Committee on Energy Conservation (member) ..... V.A. Haw (DGO)
Committee on Occupational Health and Safety (technical consultant) ..... I. Hargreaves (MSL)
Committee on Radioactive Waste Containment (member) ..... G. Larocque (MRL)
Committee on Zinc Resource Appraisal (member) ..... E.G. Joe (MSL)
Computer Science Policy Committee (member) ..... D.F. Coates (DGO)
Computer Working Committee (member) ..... F.J. Kelly (MSL)
Coordinating Committee on Environmental Matters (member) ..... J.O. Edwards (PMRL)
Coordinating Committee on Ocean Mining ..... A.L. Job (TID)
(members) ..... B.H. Lucas (MSL)
..... D.J. MacKinnon (MSL)
..... G.M. Ritcey (MSL)
Earth Wall Exhibit Committee (member) ..... C.F. Dixon (TID)
Energy Storage and Conversion, Flywheel Committee ..... E.E. Laufer (PMRL)
Electrical Coordinating Committee (member) ..... W.N. Roberts (PMRL)
Library Advisory Committee (member) ..... W.A. Pollard (PMRL)
Occupational and Environmental Research for Uranium Production, Joint Panel (secretary) ..... G. Zahary (MRL)
Oil and Gas Coordinating Committee (member) ..... D.A. Reeve (RPO)
Scientific and Technical Information Committee (member) ..... A.S. Romaniuk (TID)
Uranium Resource Appraisal Group, Steering Committee (members). V.A. Haw (DGO)
..... R. Welwood (MRL)
Subcommittee on Uranium Resource Assessment (member) ..... R. Welwood (MRL)
Subcommittee on Uranium Economics (member) ..... R. Welwood (MRL)
Subcommittee on Uranium Reserves (member) ..... R. Welwood (MRL)

DEPARTMENT OF ENVIRONMENT

Gold Mines Effluent Standards Working Group (member) ..... E.G. Joe (MSL)

DEPARTMENT OF INDUSTRY, TRADE AND COMMERCE

Technical Progress Review Group for DIP Contracts to Industry (member) ..... T.A. Wheat (MSL)

DEPARTMENT OF REGIONAL ECONOMIC EXPANSION

Management Subcommittee for New Brunswick Ore Development (member) ..... W.J.S. Craigen (MSL)

FEDERAL-PROVINCIAL COAL INVENTORIES-TECHNICAL COMMITTEES

Canada-Nova Scotia Coal Subcommittee (member) ..... T.E. Tibbetts (ERL)
Canada-Saskatchewan Coal Subcommittee (member) ..... T.E. Tibbetts (ERL)

INTERDEPARTMENTAL COMMITTEE ON FUTURES RESEARCH

(member) ..... D.F. Coates (DGO)

INTERDEPARTMENTAL COMMITTEE FOR METRIC CONVERSION

(member) ..... M.J. Lavigne (PMRL)

INTERDEPARTMENTAL COMMITTEE ON TECHNOLOGICAL FORECASTING
(CANMET representative) ..... W.J.S. Craigen (MSL)

INTERGOVERNMENT MARITIME CONSULTATIVE ORGANIZATION

Bulk Cargoes Committee (member) ..... H.F. Steger (MSL)

INTERDEPARTMENTAL TASK FORCE ON STACK HEIGHT ESTIMATION (member) .. H. Whaley (ERL)

METRIC COMMISSION (metric conversion officer) ..... B. Nebesar (MSL)

Steering Committee No. 4 (members) ..... M.J. Lavigne (PMRL)
..... B. Nebesar (MSL)
Sector Committee No. 4.1 (members) ..... M.J. Lavigne (PMRL)
..... B. Nebesar (MSL)

MINISTRY OF TRANSPORT

Technical Committee on Dangerous Goods (member) ..... J.A. Darling (MRL)
Subcommittee Advisory to Canadian Delegate to International
Maritime Consultative Organization (member) ..... J.A. Darling (MRL)

NATIONAL RESEARCH COUNCIL

Associate Committee for Aerospace Structures and Materials
(member) ..... A.J. Williams (PMRL)
Associate Committee on Geotechnical Research Subcommittee on
Muskeg (member) ..... T.E. Tibbetts (ERL)
Technical Liaison Committee on Police Equipment Subcommittee,
Section 2, Chemicals (member) ..... J.A. Darling (MRL)

ROYAL CANADIAN NAVY

Technical Committee for Steel Plates for Ship Construction
(member) ..... D.R. Bell (PMRL)

CANADA — MISCELLANEOUS

AIR INDUSTRIES ASSOCIATION OF CANADA

Materials and Process Subcommittee (member) ..... A.J. Williams (PMRL)

ALBERTA COAL MINING RESEARCH CENTRE

Technical Committee (member) ..... T.S. Cochrane (MRL)

ALBERTA RESEARCH COUNCIL

Underground Coal Gasification Advisory Committee (member) .... R.N. Chakravorty (MRL)

CAMBRIAN COLLEGE OF APPLIED ARTS AND TECHNOLOGY

Advisory Committee on Mining-Geology (member) ..... G. Zahary (MRL)
Canadian Geotechnical Society, Ottawa Geotechnical Group
Program Committee (members) ..... W.M. Gray (MRL)
..... M. Gyenge (MRL)
Subcommittee on Tunnelling (member) ..... M. Gyenge (MRL)

CANADIAN CARBONIZATION RESEARCH ASSOCIATION

(secretary) ..... J.C. Botham (ERL)
Technical Committee (secretary) ..... D.A. Reeve (RPO)

CANADIAN CERAMIC SOCIETY (director) ..... K.E. Bell (MSL)

Ceramographic Committee (chairman) ..... T.A. Wheat (MSL)
Editor-in-Chief of the Journal ..... K.E. Bell (MSL)
Associate Editor of the Journal ..... T.A. Wheat (MSL)
Editorial Committee (member) ..... T.A. Wheat (MSL)
Electronics and Basic Science Division (chairman) ..... T.A. Wheat (MSL)
Program Committee (member) ..... T.A. Wheat (MSL)

CANADIAN COAL PETROGRAPHERS GROUP (secretary) ..... B.N. Nandi (ERL)

(members) ..... J.C. Botham (ERL)
..... J.G. Jorgensen (ERL)

CANADIAN CONTINUOUS STEEL CASTINGS RESEARCH GROUP

(member) ..... R. Thomson (PMRL)

CANADIAN FRACTURE RESEARCH CORPORATION (member) ..... W. Tyson (PMRL)

CANADIAN GALVANIZING RESEARCH ASSOCIATION

(member) ..... J.O. Edwards (PMRL)

CANADIAN GAS ASSOCIATION

Standards Committee (member) ..... G.K. Lee (ERL)
Corrosion Prevention Committee (member) ..... G.J. Biefer (PMRL)

CANADIAN GAS RESEARCH INSTITUTE (director) ..... G.K. Lee

CANADIAN GEOTECHNICAL SOCIETY

Ottawa Geotechnical Group Program Committee (members) ..... W.M. Gray (MRL)
..... M. Gyenge (MRL)

CANADIAN INSTITUTE OF ENERGY (director) ..... F.D. Friedrich (ERL)

Ottawa Branch (vice-chairman) ..... T.D. Brown (ERL)

CANADIAN INSTITUTE OF MINING AND METALLURGY

Algoma Branch (secretary-treasurer) ..... P. Miles (MRL)
Bulletin Committee
(Coal Division representative) ..... A.S. Romaniuk (MRL)
(Metallurgical Society representative) ..... D.K. Faurschou (RPO)
Calgary Branch (member) ..... H.U. Bielenstein (MRL)
Canadian Metallurgical Quarterly
Publications Committee (member) ..... G.R. Hoey (MSL)
Canadian National Committee on Rock Mechanics (chairman) ..... D.F. Coates (DGO)
Central Publications Committee (members) ..... R.M. Buchanan (MSL)
..... D.K. Faurschou (RPO)
Coal Division (member) ..... T.S. Cochrane (MRL)
(member) ..... K. Feng (MRL)
Committee on Computer Applications and Process
Control (representative) ..... K. Feng (MRL)
Committee on Nominations (chairman) ..... T.S. Cochrane (MRL)
Committee on Publications (chairman) ..... T.E. Tibbetts (ERL)
Geology Division (chairman) ..... L.J. Cabri (MSL)
(secretary) ..... W. Petruk (MSL)
Technical Program Committee (chairman) ..... L.J. Cabri (MSL)
Industrial Minerals Division
Education Committee (member) ..... R.K. Collings (MSL)
Nominations Committee (chairman) ..... J.G. Brady (MSL)

Technical Program Committee (member) ..... R.K. Collings (MSL)
Iron and Steel Division (member) ..... R. Thomson (PMRL)
Metallurgical Society (president) ..... G.M. Ritcey (MSL)
Corrosion Section (member-at-large) ..... G.R. Hoey (MSL)
Editorial Board (member) ..... J.E. Dutrizac (MSL)
Executive and Board of Directors (member) ..... G.M. Ritcey (MSL
Hydrometallurgy Section Executive (members) ..... J.E. Dutrizac (MSL)
..... G.M. Ritcey (MSL)
Materials Engineering Committee (member) ..... J.D. Boyd (PMRL)
Non-Ferrous Pyrometallurgy Section (executive member) ..... A.H. Webster (MSL)
Publications Committee (chairman) ..... J.D. Boyd (PMRL)
Technical Program Committee (chairman) ..... J.E. Dutrizac (MSL)
Ottawa Branch
Executive Committee (secretary-treasurer) ..... M.C. Campbell (MSL)
(members) ..... W.J. Craigen (MSL)
..... J.J. MacKinnon (MSL)
..... W. Petruk (MSL)
..... J.T. Price (ERL)
Special Volumes Committee (chairman) ..... R.M. Buchanan (MSL)
(member) ..... J.C. Botham (ERL)
Technical Program Committee (2nd vice-chairman) ..... M.C. Campbell (MSL)
(members) ..... R.M. Buchanan (MSL)
..... D.K. Faurschou (RPO)

CANADIAN JOURNAL OF CIVIL ENGINEERING

(associate editor) ..... V.M. Malhotra (MSL)

CANADIAN LAND RECLAMATION ASSOCIATION (member) ..... D.R. Murray (MRL)

CANADIAN JOURNAL OF SPECTROSCOPY

Editorial Board (member) ..... A.H. Hardin (ERL)

CANADIAN LIBRARY ASSOCIATION

Committee on Intellectual Freedom (member) ..... J.E. Kanasy (TID)

CANADIAN MINERAL ANALYSTS ASSOCIATION (treasurer) ..... R.R. Craig (MSL)
(secretary) ..... G.A. Hunt (MSL)

CANADIAN MINERAL PROCESSORS

Executive Committee (treasurer) ..... R.W. Bruce (MSL)
(secretary) ..... E.G. Joe (MSL)
(member) ..... H.H. McCreedy (MSL)

CANADIAN MINERALOGIST, THE (co-editors) ..... L.J. Cabri (MSL)
..... J.L. Jambor (MSL)
(associate editor) ..... D.C. Harris (MSL)

CANADIAN NATIONAL COMMITTEE ON ROCK MECHANICS (secretary-treasurer) D.G.F. Hedley (MRL)

Subcommittee on Rock Breakage (member) ..... W.M. Gray (MRL)
Subcommittee on Non-Explosive Breakage Methods (member) ..... M. Gyenge (MRL)
Awards Panel Subcommittee (member) ..... G. Zahary (MRL)

CANADIAN PROBE USERS' GROUP (chairman) ..... R.H. Packwood (PMRL)

CANADIAN ROCK MECHANICS GROUP (secretary-treasurer) ..... W.M. Gray (MRL)
..... D.G.F. Hedley (MRL)
CANADIAN ROCK MECHANICS SYMPOSIUM (12th) (member) ..... D.G.F. Hedley (MRL)

CANADIAN SOCIETY FOR CHEMICAL ENGINEERING

Chemical Reaction Engineering Continuing Program
Committee (member) ..... M. Ternan (ERL)
Ottawa Section, Executive Committee (member) ..... B.B. Pruden (ERL)

CANADIAN STANDARDS ASSOCIATION

Ad hoc Committee on Positive Chimney Dampers:
Residential Heating (member) ..... T.D. Brown (ERL)
Air Pollution Control (member) ..... H. Whaley (ERL)
Aluminum and Aluminum Alloys (member) ..... W.A. Pollard (PMRL)
Analytical Methods (chairman) ..... C.H. McMaster (MSL)
Application of Statistical Methods (member) ..... R. Sutarno (MSL)
Canadian Electrical Code, Part I
Subcommittees on Sections 18, 20 and 24 (member) ..... J.A. Bossert (MRL)
Canadian Electrical Code, Part II
Explosion-Proof Enclosures for Use in Class I, Groups A, B, C and D Hazardous Locations (member) ... J.A. Bossert (MRL)
Electric Luminaires for Use in Hazardous Locations (member) ..... G. Lobay (MRL)
Electric Motors and Generators for Use in Hazardous Locations (member) ..... G. Lobay (MRL)
Combustible Gas Detection Equipment (member) ..... G. Lobay (MRL)
Intrinsically Safe and Non-Incendive Equipment for Use in Hazardous Locations (vice-chairman) ..... J.A. Bossert (MRL)
Plugs and Receptacles for Use in Hazardous Locations (member) ..... G. Lobay (MRL)
Cables to be Used in Hazardous Locations (member) ..... G. Lobay (MRL)
Canadian Electrical Code, Part V
Use of Electricity in Mines (member) ..... J.A. Bossert (MRL)
Cast Iron (member) ..... R.K. Buhr (PMRL)
Concrete Materials (chairman) ..... V.M. Malhotra (MSL)
(member) ..... G.G. Carette (MSL)
Concrete Aggregates (member) ..... H.S. Wilson (MSL)
Copper and Copper Alloys (member) ..... J.O. Edwards (PMRL)
Corrosion (chairman) ..... A.A. Winer (MSL)
Corrosivity of Insulating Materials (member) ..... G.R. Hoey (MSL)
Galvanizing of Irregularly-Shaped Articles (member) ..... J.J. Sebisty (PMRL)
Galvanizing of Wire (member) ..... J.J. Sebisty (PMRL)
Gas Pipeline Code (member) ..... K. Winterton (PMRL)
Gypsum and Lime (member) ..... R.K. Collings (MSL)
Implant Materials (member) ..... W.N. Roberts (PMRL)
Metallic Implants (Stainless Steel Orthopaedic Systems) (coordinator) ..... W.N. Roberts (PMRL)
Incinerator Performance (member) ..... F.D. Friedrich (ERL)
Installation Code for Solid Fuel Burning Equipment (member) ... E.R. Mitchell (ERL)
Lead and Lead Alloys (member) ..... A. Couture (PMRL)
Liquefied Natural Gas (member) ..... K. _interton (PMRL)
Magnesium and Magnesium Alloys (member) ..... B. Lagowski (PMRL)
Mechanical Test Methods (member) ..... P.J. Todkill (PMRL)
Mineral Thermal Insulation (member) ..... A.A. Winer (MSL)
Mineral Wool (member) ..... H.S. Wilson (MSL)
Non-Ferrous Metallurgy (chairman) ..... J.O. Edwards (PMRL)
(member) ..... C.H. McMaster (MSL)
Designations (member) ..... J.O. Edwards (PMRL)
Nuclear Power Plant Components (member) ..... L.P. Trudeau (PMRL)
Oil Pipeline Code (member) ..... K. Winterton (PMRL)
Pipeline Fracture Toughness Task Force (members) ..... D.R. Bell (PMRL)
..... L.P. Trudeau (PMRL)
Pipeline Materials (member) ..... D.R. Bell (PMRL)
Primary Nickel and Nickel Alloys (member) ..... M.J. Lavigne (PMRL)
Properties of Pipeline Materials (joint subcommittee)(member).. D.R. Bell (PMRL)
Safety in Welding and Cutting Operations (member) ..... K. Winterton (PMRL)
Sampling Emissions and Measurements (chairman) ..... H. Whaley (ERL)
Sprayed Metal Coatings (member) ..... J.J. Sebisty (PMRL)
Statistical Methods for Nuclear Material Inventory Verification (member) ..... R. Sutarno (MSL)
Steel Castings (member) ..... D.E. Parsons (PMRL)
Steel Chain (member) ..... R.K. Buhr (PMRL)
Structural Steel (member) ..... D.R. Bell (PMRL)
Task Group on Notch Toughness of Structural Steel (member) .... D.R. Bell (PMRL)
Welding Electrodes (member) ..... K. Winterton (PMRL)
Welding Inspection Organizations (member) ..... K. Winterton (PMRL)
Welding of Pipelines (joint subcommittee) (member) ..... K. Winterton (PMRL)
Zinc and Zinc Alloys (member) ..... A. Couture (PMRL)

CANADIAN SYMPOSIUM ON CATALYSIS (6th) (vice-chairman) ..... M. Ternan (ERL)

(secretary) ..... J.F. Kriz (ERL)
(registrar) ..... A.H. Hardin (ERL)
Publications (director) ..... J.F. Kelly (ERL)
Publicity (director) ..... R. Ranganathan (ERL)

CANADIAN URANIUM PRODUCERS' METALLURGICAL COMMITTEE

(secretary) ..... H.H. McCreedy (MSL)
Analytical Subcommittee (secretary) ..... J.L. Dalton (MSL)

CANADIAN WELDING SOCIETY

Working Group on Micro-Alloy Steels (member) ..... J. Gordine (PMRL)

CANADIAN ZINC AND LEAD RESEARCH COMMITTEE

(secretary) ..... J.O. Edwards (PMRL)

CENTRE FOR RESOURCE STUDIES QUEEN'S UNIVERSITY

Board of Directors (member) ..... D.F. Coates (DGO)

CHEMICAL INSTITUTE OF CANADA

Catalysis Division (secretary-treasurer) ..... M. Ternan (ERL)
Committee of Scrutineers (chairman) ..... J.C. Hole (MSL)

ELLIOT LAKE VENTILATION GROUP

(members) ..... G. Knight (MRL)
..... M. Savich (MRL)
..... M. Gangal (MRL)

ENDAKO MINES LIMITED

Research Steering Committee (member) ..... G.J. Biefer (PMRL)

HAILEYBURY SCHOOL OF MINES

Advisory Committee (member) ..... R. Tervo (MRL)

INDUSTRIAL RESEARCH ASSISTANCE PROGRAM

Canadian Steel Founders (Hawker Siddeley), Sand 446 (member) .. E.I. Szabo (PMRL)
Westinghouse Canada Ltd., Turbine 230, (liaison) ..... A.J. Williams (PMRL)

MINERALOGICAL ASSOCIATION OF CANADA

Council (ex-officio members) ..... L.J. Cabri (MSL)
..... J.L. Jambor (MSL)
Mineralogical Abstracts (contributor) ..... J.A. Soles (MSL)

NATIONAL ADVISORY COMMITTEE ON MINING AND METALLURGICAL RESEARCH

(vice-chairman) ..... D.F. Coates (DGO)
(secretary) ..... M.C. Campbell (MSL)
Physical Metallurgy Subcommittee (member) ..... H.V. Kinsey (PMRL)

PROFESSIONAL INSTITUTE OF THE PUBLIC SERVICE OF CANADA

Chemistry Group Executive (chairman) ..... G.A. Hunt (MSL)
Nominations Committee (member) ..... A.J. Gilmore (MSL)

QUEBEC ASBESTOS MINING ASSOCIATION

Technical Committees and subcommittees (member) ..... A.A. Winer (MSL)

SENIOR ELECTRICAL/MECHANICAL INSPECTORS OF MINES

(member) ..... J.A. Bossert (MRL)

SUDBURY BASIN-ELLIOT LAKE RECLAMATION STEERING COMMITTEE (member) . G. Zahary (MRL)

UNIVERSITY OF ALBERTA

Advisory Board to Mineral Engineering (member) ..... H.U. Bielenstein (MRL)

SPECTROGRAPHY SOCIETY OF CANADA

Task Committee for Reference Materials Project (member) ..... R.D. McDonald (PMRL)
Non-Ferrous Metals Task Group (member) ..... R. Thomson (PMRL)

SPECTROSCOPY SOCIETY OF CANADA

(president) ..... A.H. Hardin (ERL)
Canadian Journal of Spectroscopy (technical editor) ..... G.L. Mason (MSL)
Continuing Education Committee (chairman) ..... A.H. Hardin (ERL)
Journal Committee (members) ..... G.L. Mason (MSL)
..... A.H. Hardin (ERL)
National Executive Committee (secretary) ..... J.L. Dalton (MSL)
Ottawa Valley Section (vice chairman) ..... C.W. Smith (MSL)
Representative on SCITEC ..... B. Nebesar (MSL)
Long-term planning committee of SCITEC (member) ..... B. Nebesar (MSL)
Science Policy and Public Affairs Committee (chairman) ..... B. Nebesar (MSL)
24th Symposium (secretary) ..... T.R. Churchill (MSL)
Organizing Committee (member) ..... A.H. Hardin (ERL)

STEEL CASTINGS INSTITUTE OF CANADA

Research Committee (member) ..... R.K. Buhr (PMRL)

SUDBURY BASIN/ELLIOT LAKE RECLAMATION STEERING COMMITTEE

(members) ..... D.R. Murray (MRL)
..... G. Zahary (MRL)

SYMPOSIUM ON THE ANALYSIS OF GEOLOGIC MATERIALS

Organizing Committee (members) ..... G.A. Hunt (MSL)
..... R.G. Sabourin (MSL)

UNIVERSITY OF ALBERTA

Department of Mineral Engineering Advisory Board (member) ..... K. Barron (MRL)