THE WORK OF THE MINING RESEARCH LABORATORIES DIVISION OF CANMET - With Special Reference to Mining Health and Safety

John E. Udd

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by

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ABSTRACT

Mining research at CANMET is accomplished through two Divisions: the Coal Research Laboratories (CRL), with facilities in Sydney, Nova Scotia and Devon, Alberta; and the Mining Research Laboratories (MRL), with facilities in Bells Corners, Elliot Lake, and Sudbury, Ontario. The work of CRL is commodity-specific to coal and oil sands. MRL addresses the needs of the rest of the industry, and also national requirements for equipment and explosives certification.

In this talk, the author will give an overview of federal government mining research in the context of that work which is most relevant to mining health and safety.

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*Director, Mining Research Laboratories, CANMET, Energy, Mines and Resources Canada, Ottawa, Ontario.

Keywords

Canada, CANMET, certification, explosives testing, explosive atmospheres, health and safety, mining, Mining Research Laboratories, mining environments, research, rock mechanics

LES TRAVAUX DE LA DIVISION DES LABORATOIRES DE RECHERCHE MINIÈRE DE CANMET

- Particulièrement en relation avec la santé et la sécurité minière

par

J.E. Udd*

RÉSUMÉ

La recherche minière à CANMET est accomplie par deux de ses divisions: les Laboratoires de recherche sur le charbon (LRC), avec des installations à Sydney, Nouvelle-Ecosse et Devon, Alberta; et les Laboratoires de recherche minière à Bells Corners, Elliot Lake, et (en 1987) Sudbury, Ontario. Les travaux effectués par LRC sont reliés aux charbon et sables bitumineux. Les LRM répondent aux besoins de l'industrie, dans tous les autres domaines, ainsi qu'aux impératifs nationaux dans la certification des explosifs et de l'équipement minier.

Dans ce rapport, l'auteur survole la recherche minière du gouvernement fédéral, dans un contexte cadrant principalement avec la santé et sécurité dans les mines.

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*Directeur des Laboratoires de recherche minière, CANMET, Énergie, Mines et Ressources Canada, Ottawa, Ontario

Mots-Clés

atmosphères explosives, Canada, CANMET, certification, environnement minier, essais sur les explosifs, Laboratoires de Recherche Minière, mécanique des roches, minage, recherche, réhabilitation de parcs à résidus, santé et sécurité

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INTRODUCTION

CANMET, the acronym for the Canada Centre for Mineral and Energy Technology, is the name by which the organization was founded in 1907 as the federal Mines Branch is presently known. The name was changed in 1974, in order to give recognition to the importance of both minerals and energy technologies. A further reorganization occurred in 1987 by which CANMET was divided into three related Branches - for Energy, Minerals, and Policy and Planning. The current organizational chart is shown as Fig. 1.

The organization as a whole functions in an environment of matrix management. The five "line" Divisions report to a Director-General for either Minerals or Energy. On the Minerals side of the organization the Divisional breakdowns of responsibilities parallel the divisions of the extraction and processing process in the industry; namely, mining, mineral processing, and physical metallurgy. The energy activities are more-or-less divided between coal and hydrocarbons.

The second dimension of the organiztional matrix is composed of a number of "staff" divisions which report to the Director-General for Policy and Planning. Each of these Divisions performs a function which is common to all of the "line" divisions. For example, the Research Projects Office is responsible for monitoring the entire range of research activities of CANMET and for recommending allocations of funds for both research contracts and operating budgets.

THE CURRENT CANMET ORGANIZATIONAL CHART

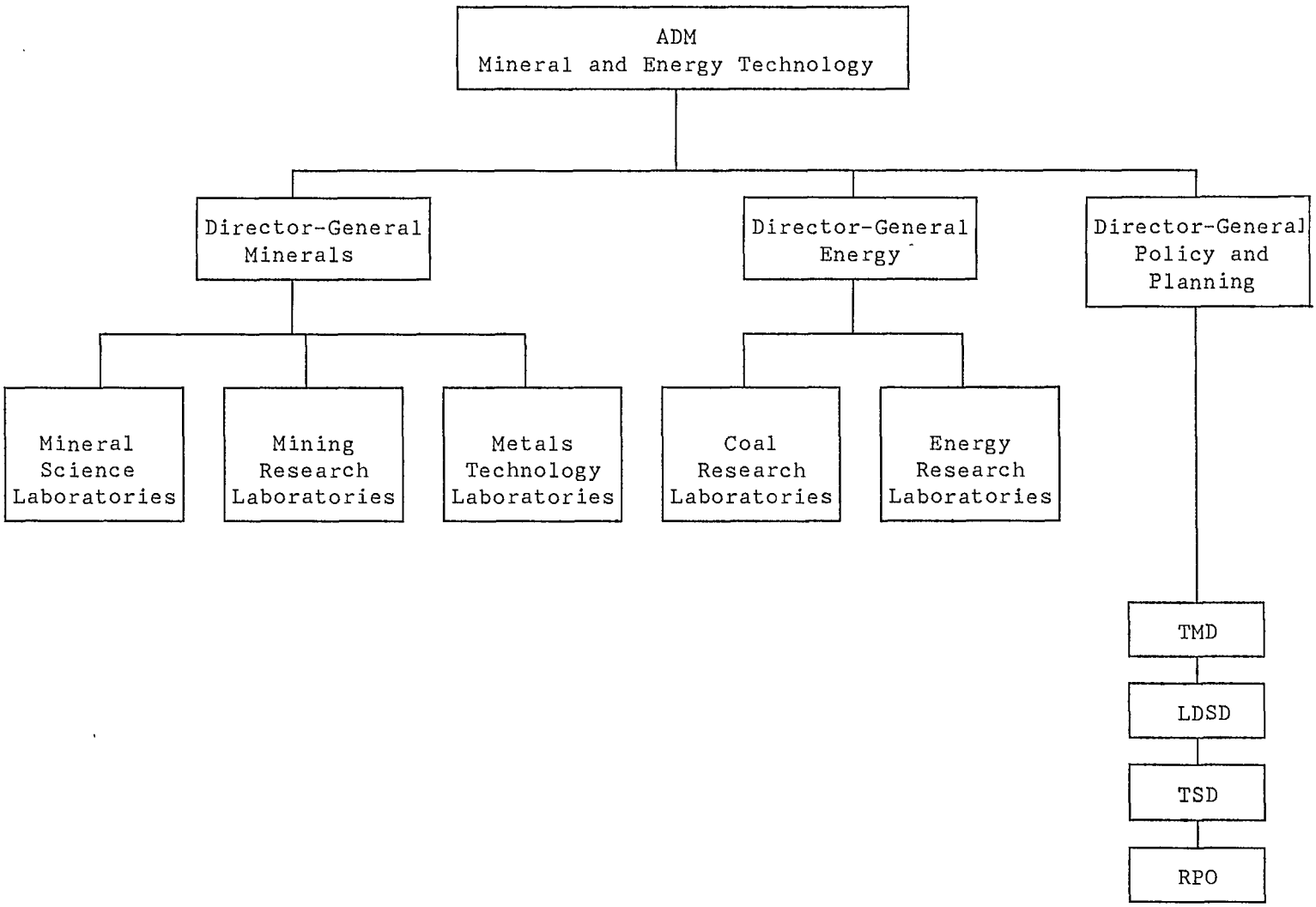

FIGURE 1

THE MANDATE AND ACTIVITIES OF CANMET

The mission of CANMET "is to perform and sponsor, in partnership with its clients, predominantly commercial and cost-shared research, technology development and technology transfer to: enhance the competitiveness of the Canadian mineral, metal and energy industries; improve health, safety and environmental control in the client industries; and support governmental policy initiatives in the national interest.

In short, the activities of CANMET, may be described as research relating to Production, Protection, and Policy. The distribution of effort is roughly 50%, 40%, and 10%, respectively, for the organization as a whole. Examples of each of these, within the work of the Mining Research Laboratories, will be described shortly (Fig. 2).

MINING RESEARCH AT CANMET

Mining Research in CANMET is accomplished through two divisions - the Mining Research Laboratories and the Coal Research Laboratories. The latter Division, established early in the 1980's, performs work in both mining and processing which is related specifically to coal and oil sands. Other mining research, specifically hard-rock industrial minerals, and evaporites, is within the mandate of the former. A diagram showing the organization of CANMET's mining research is shown in Fig. 3.

THE RESEARCH ACTIVITIES OF CANMET

PRODUCTION

Enhance the competitiveness of the Canadian mineral, metal and energy industries.

PROTECTION

Improve health, safety and environmental control in the client industries.

POLICY

Support governmental policy initiatives in the national interest.

FIGURE 2

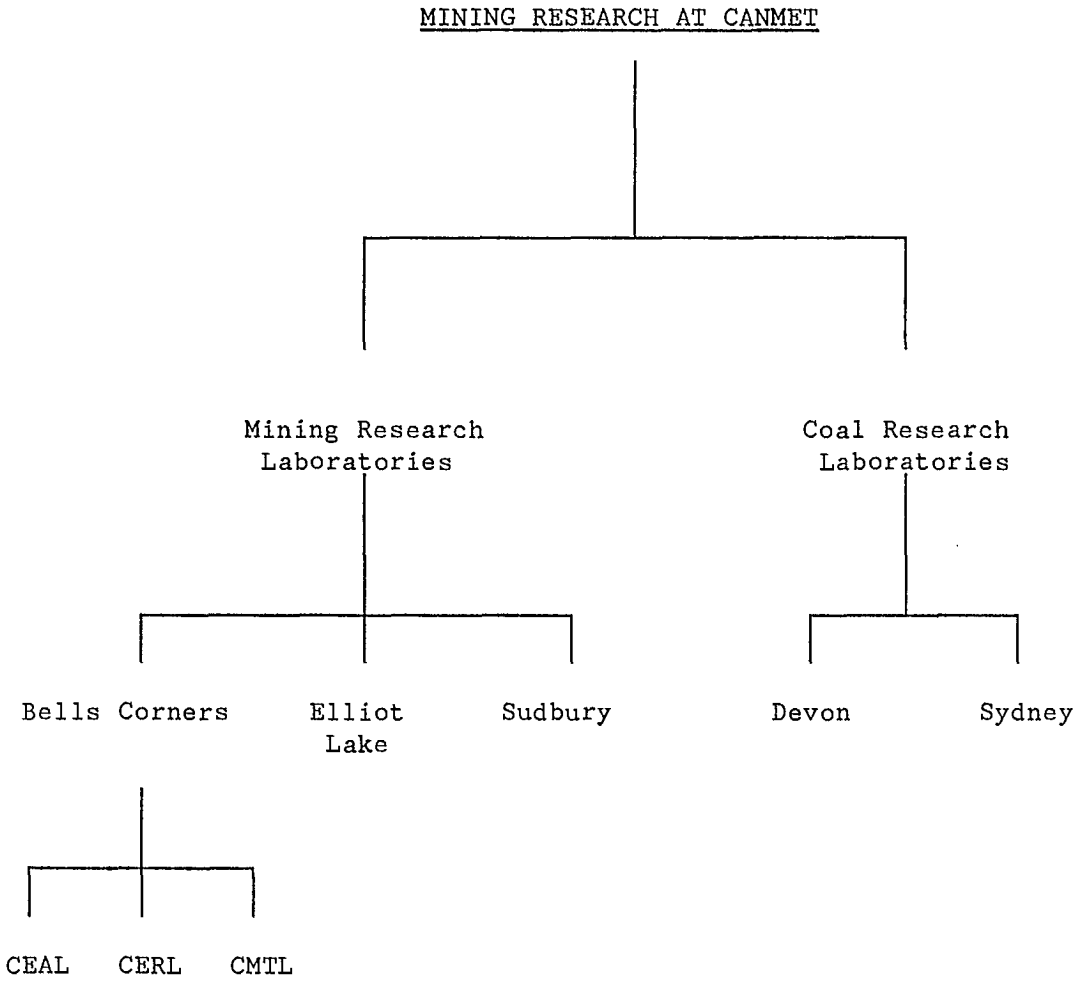
MINING RESEARCH AT CANMET
Mining Research Laboratories
Coal Research Laboratories
Bells Corners
Elliot Lake
Sudbury
Devon
Sydney
CEAL
CERL
CMTL

FIGURE 3

The Mining Research Laboratories are comprised of five units. Three of these, the Canadian Explosive Atmospheres Laboratory, the Canadian Explosives Research Laboratory, and the Canadian Mine Technology Laboratory, are situated at the Bells Corners Complex, in Nepean, Ontario, in the National Capital Region. The major field unit, the Elliot Lake Laboratory has been situated at that location since 1965. A small laboratory, to address mine backfill research, became operational on the campus of Laurentian University, in Sudbury, late in 1987.

THE MINING RESEARCH LABORATORIES DIVISION OF CANMET

During 1988-1989 the authorized complement of the Division is 90.33. Exclusive of salaries and allocations for research contracts, the operating budget for the same period is $1600.30 million. The resource allocations are shown in the summary in Fig. 4.

The research work of the division spans a broad spectrum and address on many of the key technological issues and challenges that are confronting the industry. Some of the work, in fact, relates to national needs for R&D which are broader than those of the mining industry alone. The testing of explosives for certification purposes and studies of dust explosions are two examples which perhaps best illustrate this point. A summary of the titles of current research projects, arranged according to subject areas, is given in Fig. 5.

The projects, however, are not necessarily exclusive to the individual laboratories. Some of the projects are sufficiently broad and large as to necessitate the use of personnel from more than one unit. The projects in rock mechanics and mining environments exemplify the multi-disciplinary approach which is often necessary.

DISTRIBUTION OF RESOURCES
MINING RESEARCH LABORATORIES
1988 - 1989

PERSON YEARS (by Laboratory)	HQ	CMTL	CEAL	CERL	ELL	TOTAL
Professional	3	25	7.33	6	11	52.33
Technical	0	3	5	7	10	25
Admin. Support	5	2	1	1	4	13
	8	30	13.33	14	25	90.33
PERSON YEARS (by Activity)						
Explosives	0	0	0	14	0	14
Minerals	8	29	12.33	0	25	74.33
Energy	0	0	1	0	0	1
MDA	0	1	0	0	0	1
	8	30	13.33	14	25	90.33
BUDGET ($K)						
Explosives AO&M	0	0	0	91	0	91
Capital	0	0	0	38	0	38
Minerals AO&M	180	305.5	120.0	0	307	912.5
Capital	141	112.3	0.0	0	25	278.3
Energy AO&M	0	0	40	0	0	40
Capital	135	0	40	0	0	175
MDA AO&M	0	35.5	0	0	0	35.5
Capital	0	30	0	0	0	30.0

Operating Budget (Exclusive of Salaries) 1987/88 1600.30

TOTAL 1600.30

*Part-time basis

FIGURE 4

MINING RESEARCH LABORATORIES - PROJECTS

PROJECT TITLE

Explosives Technology
- Certification & Technical Advice
- Explosives R&D

Mining Methods and Equipment
- Mine Methods and Evaluation
- Advances Mine Equipment Technology
- Canadian Mine Technology Coordination
- Materials Handling & Operations Research
- Evaporite Mining Methods
- New Brunswick MDA

Rock Mechanics
- Mine and Regional Stability
- Rock Mass Characterization
- Rock Properties and Support Systems
- Numerical Model Development
- Underground Nuclear Waste Repository
- Fragmentation
- Instrumentation Development
- Manitoba MDA
- Rockburst Research
- Ontario MDA

PROJECT TITLE

Mine Environment
- Ventilation and Respirable Dust
- Radiation

Mineral Reserves Assessment
- Reserves Assessment

EXPLOSIVE ATMOSPHERES
- Fire and Explosion Hazard R&D
- Diesel Flameproof and Emissions R&D

Equipment Safety Certification
- Equipment Certification and Testing
- Quality Assurance
- Standards Development

ENVIRONMENTAL CONTROLS
- Mine/Mill Waste Management

FIGURE 5

CANADIAN EXPLOSIVE ATMOSPHERES LABORATORY (BELLS CORNERS)

. Certification

  - diesels

  - conveyor belts

  - ducting

  - cables

  - hydraulic fluids

. Diesel exhaust pollutants research and pollutant reduction devices

. Dust explosions research - causes and control strategies

. Development of certification - material and equipment standards

FIGURE 6

CANADIAN EXPLOSIVES RESEARCH LABORATORY (BELLS CORNERS)

- Explosives, pyrotechnics, and ammunition certification
- Procedures for explosives testing
- Investigations of explosive accidents
- Development of theoretical explosive models
- Study of explosive stability
- Explosive technology for industry

FIGURE 7

CANADIAN MINE TECHNOLOGY LABORATORY (BELLS CORNERS)

- Mining technology reviews and surveys
- Impact of new technology on mining
- Evaluation of new mining technology
- Ore reserves assessments
- Numerical models for structural analysis
- Development standard of rock property test methods
- Nuclear waste disposal geotechnology

FIGURE 8

ELLIOT LAKE LABORATORY

. Control of rockbursts in mines

. Underground support systems

. Field instrumentation development

. Ground design guidelines

. Heavy metals migration in tailings and control

. Tailings revegetation

. Ventilation and respirable dust studies and control strategies

. National facility for radiation instrumentation calibration

FIGURE 9

SUDBURY LABORATORY

. Mine backfill

FIGURE 10

COAL RESEARCH LABORATORY (DEVON)

- Open pit mining
- Rock/gas outbursts
- Submarine subsidence
- Gateroad behaviour
- Slope design and stability
- Dump & spoil pile stability
- Geomechanical response to in-situ Athabaska Oil Sand's bitumen recovery

FIGURE 11

COAL RESEARCH LABORATORY (SYDNEY)

- Rock/gas outbursts
- Strata mechanics
- Subsidence & interaction monitoring
- Main roadway intersections & support
- Arch spacing and bolting
- Pick wear - rock hardness
- Long-term tunnel monitoring

FIGURE 12

The various project areas which are the concerns of the individual laboratories are listed in Fig. 6 to 10. For the sake of completeness the projects within the purview of the Coal Research Laboratories Division are also listed in Figs. 11 and 12.

In brief, in alphabetical order, each of the laboratories fulfills the following roles:

1) Canadian Explosive Atmospheres Laboratory, CEAL

CEAL provides a national service for the testing and certification of equipment and materials which are destined for use in explosive atmospheres (i.e., gassy mines). Originally, the work was devoted almost exclusively to equipment for coal mines. Recently, however, work has been added on the phenomena of dust explosions (including sulphides and ferrosilicon) and diesel emissions. The present scope, therefore, addresses a wide range of national needs (Fig. 13).

In a mining context the testing and certification work covers; flameproof mining equipment, electrical devices, mine ducting, hydraulic fluids, and conveyor belts. The importance of the latter can not be overstated in view of the economic losses to the industry in recent years because of conveyor belt fires.

The laboratory also provides technical assistance and guidance concerning a wide range of circumstances in which explosive atmospheres can be involved. These have included; ship-board explosions; explosive dusts in ferrosilicon plants and base metal mines; and gassy atmospheres in salt and potash mines. The potash mines are located in Brazil, and the provision of this service (on a cost-recovery basis) illustrates the international demands that are often placed on MRL's talents.

CANADIAN EXPLOSIVE ATMOSPHERES LABORATORY (CEAL), BELLS CORNERS

- National service for testing and certification of equipment and materials for use in explosive atmospheres.

- Development of equipment and materials to reduce hazards to health and safety of underground miners.

FIGURE 13

At present, CEAL is also very much involved in the final stages of commercialization of diesel exhaust emissions reduction technology. The work began several years ago through the certification of diesel engines for use in coal mines. On realizing that an opportunity lay in the development of techniques for the removal of soot from exhaust gases, the research developed along those lines. Subsequently, through encouraging and participating in the development of both a highly-efficient auto-regenerating ceramic filter and a venturi scrubber, CEAL has attained a reputation as a world leader. The potential impacts of these devices, and particularly the ceramic filter, are very great.

At times it is very difficult to categorize research neatly into the classifications of policy, protection, or production. The development of diesel emissions reduction devices is an excellent example of this. Beyond any question, the work addresses health and safety in mines. At the same time, because the work will result in cleaner air and enhanced efficiency, there are also productivity implications. It is a matter of opinion as to how the final accounting according to missions should be made.

2) Canadian Explosives Research Laboratory, CERL

This unit also performs work which is mostly health and safety related but which has productivity implications. The primary function, however, is to provide a service to confirm the safety characteristics of all explosives submitted for certification under the Canada Explosives Act. These include ammunition, blasting agents and commercial explosives, and pyrotechnics. It can truthfully be said that nearly all Canadians have derived some benefits from CERL's work.

The unit is also involved in research directed towards improved testing methods and the provision of advice and research concerning the storage, handling, and transportation of explosives (Fig. 14).

3) Canadian Mine Technology Laboratory, CMTL

Formerly known as the Rock Mechanics Laboratory, the unit's name was changed in 1986 to reflect the broad range of research interests and services which are provided. These cover topics which can be classified in all three areas of policy, protection, and production research (Fig. 15).

In support of policy requirements, CMTL provides periodic assessments of the national reserves of uranium and of the impacts of alternative price levels upon these. Evaluations are also made of the impacts of evolving production technologies and of mineability. Data from these studies form part of the national input into international discussions on the availability of nuclear energy.

CMTL also performs work which is in the area of public health and safety. Foremost among these are studies of the engineering properties of plutonic rocks from areas of the types which could be used for the underground disposal of nuclear wastes. "Could" is the appropriate choice of wording for, while Canada has chosen the option of burial in plutonic rocks, no specific site has been chosen. Rather, the studies relate to these types of sites generally.

CANADIAN EXPLOSIVES RESEARCH LABORATORY (CERL), BELLS CORNERS

- National service to confirm safety characteristics of all explosives submitted for certification under the Canada Explosives Act.

- Advancement of technology related to manufacture, storage, transportation and use of explosives.

FIGURE 14

CANADIAN MINE TECHNOLOGY LABORATORY (CMTL), BELLS CORNERS

- Meeting policy requirements for information on: mineability, production capabilities, uranium reserves, databases.

- Provision of specialized geotechnical studies and services:
  - Underground nuclear waste repository,
  - National rock strength testing facility,
  - numerical model development.

  - Studies of operational technology:
  - "Index" of Mining Technology Development,
  - mechanization and automation,
  - enhanced technology.

FIGURE 15

Other safety-related research in progress at CMTL includes: the development of guidelines for the design of surface crown pillars; studies of subsidence over potash mines; mine stablility studies generally, the development of rock mechanics monitoring instrumentation; and mine environmental monitoring.

Production-related research in the unit is being accomplished through a group assigned to projects in the general area of mining methods and equipment. To date, the principal thrusts have been in determining the totality of the national efforts in technology development and in sponsoring incremental advances to alternative methodologies. The former are now described in a document published annually, entitled the "Index of Mining Technology Development". Now in its fourth edition, the Index lists all projects which are known to be in progress throughout the entire Canadian industry. The individual listings, by organization, include very brief descriptions of projects together with the names, addresses, and telephone numbers of designated contact persons. All projects are also indexed according to topic areas. The objective is to facilitate the flow of information and technology transfer.

Incremental technology has been addressed through sponsoring research directed at alternative approaches to the methods which are traditional to the mining process and cycle. To date, MRL's mandate has not included the development of mining equipment. Rather, it has focussed on aspects of some of the basic processes - such as in drilling and blasting. There have been strong pressures from the industry, however, to become more involved with developmental work for mining equipment - particularly that which is needed for small mines.

Finally, the work of CMTL has always had a strong orientation towards rock mechanics. Research has included the development of new and improved methods of strength properties testing and numerical models for the analyses of stresses in rock masses around mining excavations. Both the rock testing and numerical models groups have national reputations for their contributions.

Early in 1987 one of the most modern testing machines in the world was commissioned in the CMTL laboratories. This state-of-the-art stiff testing machine, with its capabilities for triaxial tests under high confinements and elevated temperatures, is viewed as a national resource for specialized studies. It is available for the use of others on a cost-recovery basis. It has been in full-time constant use since it was installed. Demands are such for the capabilities provided that a second shift of operation - almost unheard of for a testing machine - may become necessary.

4) Elliot Lake Laboratory, ELL

Since its inception, in 1965, the Elliot Lake laboratory has been well-known for the contributions of its researchers in rock mechanics and mining environments. More recently, work on the management and rehabilitation of mine and mill wastes has been added (Fig. 16). This latter group is the smallest of the three sections but its importance will probably grow as a national thrust into work on mine environment neutral drainage (the "MEND" program) is initiated. The program, designed on a collaborative basis with the industry and other governments, is now being promoted by the Mining Association of Canada.

ELLIOT LAKE LABORATORY (ELL), ELLIOT LAKE

- Develop technology for improvement of underground environment (Radiation, Dust, ...)
- National facility for calibration of radiation instrumentation
- Applications of rock mechanics to mine design
- Improvement of mine stability
- National Centre of Excellence in Rockburst Research
- Largest rock testing machine in Canada
- Management of mine/mill wastes

FIGURE 16

During the more than 20 years of its existence, the Elliot Lake laboratory has been renowned for the advances in rock mechanics which have come from it. The pioneering studies on room-and-pillar mining in hard-rock stratiform deposits are now the basis for a design approach which is used internationally. Earlier, the laboratory was also known for work on rock mechanics instrumentation. Unfortunately, these thrusts were not maintained and some of the momentum was lost. The Division plans to reactivate this aspect of the work, however, at the earliest opportunity.

The Elliot Lake laboratory also includes among its equipment the largest rock testing machine in Canada. With a compression loading capacity of 4,000,000 lb-f the machine permits the staff to undertake studies on very large specimens (by rock mechanics standards). By doing this, it is possible to address some of the key issues of size effects.

The unit is also known for the research efforts in mine environments. For many years, a sizeable group has addressed problems relating to dust, noise, and radiation. The latter is a natural consequence of being located in the key centre of Canadian uranium production. Recently, as a part of a relocation to new and vastly-improved facilities, a national facility for the calibration of radiation instrumentation has been added to the unit's capabilities. This new facility is now in the final stages of construction. Other changes to the work of ELL include the termination of research into noise and vibrations and the implementation of a cooperative major thrust into rockburst research. The latter, a $4.2 million, 5-year project, is jointly funded (on a tri-partite basis) by the Province of Ontario and the industry of that province. It is now entering the final year covered by the initial plan. A proposal, for a renewal, is being written in collaboration with all of the various industrial and governmental partners.

SUDBURY LABORATORY (SBL), SUDBURY

- Provides supporting studies in backfill research for Ontario M.D.A. projects

FIGURE 17

5) Sudbury Laboratory, SBL

During the past four years there has been an increasing emphasis on field-scale projects in the mines. Most of the momentum has resulted from the federal/provincial Mineral Development Agreements, which have been particularly supportive of field-scale projects directed towards improving protection and production technologies.

In Ontario, a concentration of applied work on backfill research is now in progress. Because of this, the decision was made to install a small unit in Sudbury. Located on the campus of Laurentian University of Sudbury, the laboratory became operational late in 1987. Initially, its work relates almost exclusively to studies of the properties of mine backfill (Fig. 17).

RESEARCH THROUGH THE FEDERAL/PROVINCIAL MINERAL DEVELOPMENT AGREEMENTS (MDA'S)

In the mid 1980's a series of Economic Development Agreements (EDA's) were negotiated between the federal government and the various provincial and territorial governments. Each of these agreements have subsidiary agreements covering various sectors of the economy. In several of the political jurisdictions these are Mineral Development Agreements - known as MDA's.

In several of the MDA's, provision was made for research on topics which would enhance mining productivity and technology. It must be emphasized that the topics were selected through consultations with both local industry and provincial and territorial government counterparts. Because the agreements were negotiated between mines ministries the topics selected, for the most part, relate to mining productivity and technology. In modern practice, improved productivity and safety can not be separated. Most, if not all of the topics, as listed in Figures 18 to 22, therefore have health and safety implications.

Some, however, are heavily orientated to health and safety research, and I would like to discuss these in some detail.

The first of these, the Canada/Ontario/Industry Rockburst Research Project was originally intended to be an MDA project. During the period when discussions with the province were taking place, however, two major rockbursts in the Sudbury basin caused loss of life and extensive damage. Because of this it became urgent to proceed with research as quickly as possible. The project, as a result, was detached from the MDA and given an individual identity.

1. Canada/Ontario/Industry Rockburst Research Projects

As the result of the seismic events which took place in Ontario mines, in the early 1980's, an intensification of rockburst research became necessary. In May of 1984, at a consultative meeting between CANMET, industry, and representatives of the Ontario Government, this was identified as the highest priority for research.

After a series of meetings with representatives of the Government of Ontario and of the companies which had experienced severe rockbursting, a Memorandum of Understanding was signed in 1985. Under it, CANMET is providing a team of 5 persons dedicated to the project for 5 years, together with operating funds. The Government of the Province of Ontario, is contributing up to $1.4 million for the purchase of capital equipment and services. The Industry of the province of Ontario is also providing a matching contribution, with a value of up to $1.4 million, through the provision of monies, goods, and services, to the project.

Now in the fourth year, it is clear that more is being committed to the project than was originally visualized. The industry, in particular, has made a major commitment to the installation and upgrading of local mine monitoring systems.

The research has proceeded along three lines:

1) By enhancing the seismic monitoring capabilities in all major mining camps in Ontario. A very high priority is to develop a seismic monitoring system that will capture complete waveforms, as compared with triggered first arrivals and provide information on first motion, peak particle velocity, and seismic energy.

2) By alleviating the problem of local mine monitoring systems being saturated with the signals coming from large rockbursts. Improved local coverage is being incorporated into the Eastern Canada Seismic Network by the of addition of monitoring stations in the Sudbury basin. Data from these stations are being transmitted to Science North, in Sudbury, and also to the Geophysics Division of the Geological Survey of Canada, in Ottawa. Seismograph stations are also being installed at Red Lake and Kirkland Lake to provide improved coverage for these mining camps.

3) Between the seismic stations of the Eastern Canada grid at one end of the scale, and the local mine microseismic monitoring systems at the other, there is a need for an intermediate out-of-mine system having the capability of being able to record the complete waveforms of large seismic events.

Macroseismic systems of this kind have now been installed; at Falconbridge's Strathcona Mine and INCO's Creighton Mine, both in the Sudbury basin (Fig. 3); at Rio Algoma's Quirke Mine, at Elliot Lake; at Campbell Red Lake Mines, at Balmertown; and at the Macassa Mine, in Kirkland Lake. Waveforms from large local events are being stored on computers at these sites and down-loaded daily to CANMET's Elliot Lake Laboratory via telephone.

The objectives of the Canada/Ontario/Industry rockburst research project are to add to our knowledge of the causes, origins, effects, energy sources, and mechanisms of rockbursts. The information to be derived from the three levels of monitoring systems will permit much greater accuracy in locating the origins of mining-induced seismic events. Macroseismic systems, in particular, will be very valuable when events occur outside of existing microseismic sensor arrays. Likewise, the recording of complete waveforms will permit determinations of peak particle velocities and seismic energies liberated. This will add considerably to our knowledge of the driving forces and the mechanisms involved.

2. Communication Systems for Isolated Areas in Mines, Especially in Ore-bodies Composed of Multi-lenses - Canada/Manitoba MDA

There is perhaps no other MDA underground mining research project that has generated more interest than the present research on underground communications systems. There is a very strong consensus that improved and integrated voice and data communications systems are needed urgently if progress is to be made towards effective mine information and monitoring systems.

The implications for both worker health and safety and efficiency are simply enormous. An improved voice communications system would permit instantaneous conversations with crews or workers working in isolated areas. It would also permit rapid identification of problems with conditions or equipment and permit speedy solutions to be implemented. No mine supervisor needs to be told of the costs of large production resulting from delays in obtaining urgently-needed repairs to equipment.

Likewise, a highly efficient data communications system would accelerate the development of large-scale mine information and monitoring systems.

Against this background, the interest in the awarding of a $429,400 contract to Sherritt Gordon Mines Ltd. (with Falconbridge Ltd. as a sub-contractor) can be appreciated. In the first stage of the project, the contractor was required to review the state-of-the-art in available underground mine communications systems, and to select the most suitable and cost-effective of those for an extended field trial in a Manitoba mine. After a period of evaluation, recommendations were to be made for any research and development that might be needed to improve the technology.

The report of the first phase of the work, by Falconbridge Ltd. for Sherritt Gordon, was concluded at the end of 1985. The interest in it was so great that the supply of two hundred copies printed for distribution was soon exhausted!

In the conclusions for Phase 1, it was stated that a medium frequency frequency-modulated system (FM-MF) was the best choice for mine-wide communications. It was also stated that the benefits of installing such a system would be so great that a payback period of less than two years could be anticipated.

Subsequently, in the second phase of the work, systems were purchased for voice, hoist, data, and rock mechanics monitoring communications.

The Montan-Forschung radio system was tested in a pilot area on the 320 LW level and, after having been found to be satisfactory, was expanded to full-scale installations on the 660 and 860 levels. It has been found to be capable of providing good communications but maintenance - particularly of the antenna - is especially important.

On another front, the FEMCO Trolley phone/cage phone system was purchased and is now in the first stages of installation and commissioning. A Montan-Forschung data system has also been purchased and remains to be installed on mobile equipment and evaluated.

Finally, a radio-transmitter manufactured by IMS Electronics Inc., and intended for monitoring of rock mechanics instrumentation, has been purchased and installed. Operating in conjunction with the Montan-Forschung system, it has been tested successfully. It is, however, dependent on the radio system and a successful installation of the latter is critical to its success.

Even at present, and while not yet complete, the research has had a tremendous impact on the industry. Systems of the type recommended have already been installed by both Falconbridge and INCO, in the Sudbury basin, and by Kiena. Other operators are reported to be considering installations. Seminars on the topic of mining communications have been organized by the Mines Accident Prevention Association of Ontario (MAPAO), the Algoma Branch of the CIM, and the Ontario Ministry of Labour.

From a technology transfer point of view the successes to date has been outstanding. More remains to be done, however, in convincing workers of the positive effects that monitoring will have on both health and safety and productivity. Some resistance to the technology has been encountered. This must be overcome if the new technology is to be used successfully.

3. CO_2 Surrogate - Canada/New Brunswick MDA

In Canadian mines recirculation ventilation offers the possibility of achieving substantial savings on the costs of heating mine air. One of the key concerns, however, is the extent to which air can, and should, become polluted.

Previously, in a cooperative project on diesel emissions (involving Canadian and American scientists), it was demonstrated that the concentration of all of the major exhaust pollutants were functions of CO_2 concentations. The measurement of carbon dioxide concentrations, therefore, offers the possibility of simple and less

expensive systems for mine monitoring and, eventually, automated control. Measurements of all of the pollution constituents is laborious, costly, and expensive.

In this study, which is the subject of a $107,000 contract with Brunswick Mining and Smelting through the Canada/New Brunswick MDA, the pollutants in the air in a mine level on which several machines are operating is being characterized. The objective is to determine the limits of the relationships between concentrations.

As a second stage, assuming that positive results are obtained, an automated ventilation system will be designed. The results and the technology will be applicable to many Canadian mining operations - and especially to those in the north in which the conservation of heat is a key issue.

As a part of the project "CO_2 Surrogate" considerable emphasis has been put on the ventilation modelling aspect of the project. The design of a ventilation model using the CANMET Thermodynamic ventilation model as the engine, along with AutoCad as the user-interface, has been completed. Programming has started and the first version will be computed in January, 1989.

Noranda comments that the CANMET ventilation program finds application in all of their operations.

4. Non-destructive Testing of Mine-shaft Wire-ropes
   - Canada/New Brunswick MDA

The objectives of this project is to enhance the understanding of the basic capabilities of various mine shaft wire rope non-destructive testing (NDT) instruments, and of the associated chart evaluation techniques which are used in Canadian practice in general, and New Brunswick in particular.

A series of laboratory and in-situ non-destructive wire rope examinations will be performed on ropes that characterize the sizes (from 1/2 inch to 2-1/4 inches) and constructions most widely used in New Brunswick mines. Many of the rope samples needed will be tested in-situ in New Brunswick. Laboratory tests will also be performed on rope samples exhibiting both operational and artificial anomalies. It is intended that the instruments to be used for the NDT of the wire ropes include the Canadian testing instruments, Rotesco AC, Rotescograph and Magnograph, the American LMA series instrument of NDT Technologies Inc., and the latest version of the German WBK-Seilprufstelle instrument. The European tester is of interest because it has recently been redesigned at a heavy cost. It is desirable that this project benefit from any such improvements.

The instrument Performance Standards and the number of rope samples tested will be in accordance with "The Performance Requirements for Electro-Magnetic Mine Shaft Wire Rope Testing Devices" of the Ontario Ministry of Labour, Mining Health and Safety Branch.

Instrument operators will be nominated by the instrument designers/makers themselves.

Destructive testing of wire ropes will be done in the laboratory of Wire Rope Industries Ltd. at Montreal in a manner designated by provincial legislation.

The project is being monitored and controlled by a steering Committee composed of representatives of the Province of New Brunswick, CANMET, Tektrend (the principal contractor) and one or two experts from the principal sub-contractor (Wire Rope Industries Ltd.).

After signing the contract for this project on July 4, 1988, progress has been very satisfactory. Field tests have, so far, been performed on five operational ropes at several mine sites, including two in New Brunswick. Some of these ropes are already on their way for

laboratory testing. Moreover, details have been settled of the type of artificial defects that are to be introduced in the test ropes. The latter are to be produced by late December, 1988.

The Steering Committee has met twice so far (on July 28 and October 3, 1988). Minutes of these meetings are available on request. They contain detailed information about progress to date.

CANADA/MANITOBA MDA - PROJECTS ON ROCK MECHANICS
GROUND CONTROL, AND MINE COMMUNICATIONS

Project B.2.1.1: "Design Guidelines for the VBM Method for a Steeply-Dipping Deposit in Manitoba". (Also "Procedures for blasting down hang-ups in ore passes and chutes")

Project B.2.1.2: "Development of a Geomechanical Data-Base for Ground Control in Deep Mines"

Project B.2.1.3: "Evaluation of Methods for Delayed Backfill Consolidation"

Project B.2.1.4: "Ground Stability Evaluation with Particular Reference to En-Enchelon Lensed Orebodies"

Project B.2.1.5: "Optimization of Blast Design for Blasthole Mining Operations"

Project B.2.2.1: "Communication Systems for Isolated Areas in Mines, Especially in Ore-bodies Composed of Multi-lenses"

FIGURE 18

CANADA/ONTARIO MDA

- PROJECTS ON MINE BACKFILL AND ANALYTICAL MODELS

Projects C.1.0(a) and (b): "In-Situ Determination of Dewatered Tailing Fill Properties"

Project C.2.0: "In-Situ Monitoring and Computer Modelling of a cemented sill mat and confines during tertiary pillar recovery"

Project C.3.0: "Use of Cemented Fills for Controlling Violent Failure in Pillars"

Project C.4.0: "Computer Program Specifications for the Ontario Mining Industry"

Project C.5.0: "In-Situ Properties of Backfill Alternatives in Ontario Mines"

Project C.6.0: "3-D Numerical Models for simulation of Bulk Mining at Depth"

Project C.7.0: "Liquefaction Potential of Dense Backfill"

FIGURE 19

CANADA/NEW BRUNSWICK MDA

- PROJECTS ON POTASH MINING, CO_2 SURROGATE, AND NDT OF WIRE-ROPES

Project II.5: "Use of Backfill in New Brunswick Potash Mines"

Project: "CO_2 Surrogate"

Project II.14: "Non-destructive Testing of Mine-Shaft Wire Ropes"

FIGURE 20

CANADA/NORTHWEST TERRITORIES EDA

- PROJECTS ON PILLAR RECOVERY IN PERMAFROST

Project: "Pillar Recovery in Permafrost"

Project: "Numerical Modelling of Pillar Recovery in Permafrost"

FIGURE 21

CANADA/SASKATCHEWAN MDA

- PROJECTS FOR POTASH MINING

Project: "Research on Microseismic Technology"

Project: "Regional Subsidence Related to Potash Mining

FIGURE 22

CONCLUSION

In this paper, the author has reviewed the research that is presently being conducted, either in or through the Mining Research Laboratories of CANMET. The principal focus of the paper has been on those aspects which relate to health and safety topics. Almost 40% of the Division's efforts are directed to addressing governmental objectives concerning health and safety and the environment.

In the presentation, particular emphasis has been placed on large-scale field-demonstration projects, on mine communications, rockbursts, CO_2 studies, and wire-rope testing, which have been made possible through a relatively new research-delivery vehicle: the Federal/Provincial (and Territorial) Mineral Development Agreements. Increasingly, Mines Inspectorates are becoming more aware of, and interested in, the research possibilities afforded by the MDA's.

Thus far, most MDA projects have been related to mining technology and productivity enhancement. Since the discussions which led to the definitions of these projects were between mines ministries at both the federal and provincial levels of government this is hardly surprising. With better communications, involving Ministries of Labour, however, there could be increased possibilities for including more research which relates more directly to issues of mining health and safety.