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APPLIED ROCK MECHANICS RESEARCH AT CANMET - PROJECTS IN PROGRESS THROUGH FEDERAL/PROVINCIAL MDA AGREEMENTS

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APPLIED ROCK MECHANICS RESEARCH AT CANMET

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by

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ABSTRACT

During the past three years, applied rock mechanics projects in the mines have been initiated in several provinces through Federal/Provincial Mineral Development Agreements. Work is presently in progress in Manitoba, Ontario, New Brunswick, and Saskatchewan. Other projects are being developed for possible implementation.

All of the projects address stated industrial needs and were started after consultations with industry and for provincial mining associations. The results will, therefore, be directly relevant to present needs. Additional benefits to CANMET/MRL are that a greater proportion of research is being done externally and that communications with the industry have improved.

In this paper, the author reviews the projects that have been commenced thus far.

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Keywords

backfill, blast design, ground control, Manitoba, microseismic, mine communications, Mineral Development Agreements, mining research, New Brunswick, numerical models, Ontario, research, rock mechanics, Saskatchewan, software

RECHERCHE APPLIQUÉE SUR LA MÉCANIQUE DES ROCHES AU CANMET - PROJETS EN COURS DANS LE CADRE D'ENTENTE FÉDÉRALES-PROVINCIALES SUR L'EXPLOITATION MINÉRALE

par

J.E. Udd*

RÉSUMÉ

Au cours des trois dernières années, des projets de recherche appliquée sur la mécanique des roches dans les mines ont été mis sur pied dans plusieurs provinces par l'entremise d'Ententes fédérales-provinciales sur l'exploitation minérale. Des travaux sont en cours au Manitoba, en Ontario, au Nouveau-Brunswick et la Saskatchewan. D'autres projets sont actuellement élaborés en vue d'une mise en oeuvre éventuelle.

Tous les projets répondaient à des besoins industriels et ont été amorcés après une consultation avec l'industrie pour le compte des associations minières provinciales. Par conséquent, les résultats s'appliqueront directement aux besoins actuels. De plus, grâce à ces ententes, une plus grande partie de la recherche est effectuée à l'extérieur des LRM du CANMET et ces derniers entretiennent de meilleurs rapports avec l'industrie.

Dans ce document, l'auteur passe en revue les divers projets en cours.

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Mots-Clés

terre de remblayage, conception de trou de mine, contrôle des terrains, Manitoba, microsismique, communications dans les mines, Ententes sur l'exploitation minérale, recherche minière, Nouveau-Brunswick, modèles numériques, Ontario, recherche, mécanique des roches, Saskatchewan, logiciel

TABLE OF CONTENTS

Table of Contents (cont'd)

INTRODUCTION

Since the recent recession, the Canadian mining industry has been forced to continually seek ways to improve its cost effectiveness and competitive position. While the costs of labour, goods, and services have continued to rise, the prices realized for the end products have remained at near historic lows. In this climate, the survival of an enterprise lies in improved productivity and efficiency.

Increasingly, the industry has converted to large-scale low-cost methods of bulk mining. Because of the exhaustion of near-surface reserves of ore, ore bodies at greater depths and under more adverse geological conditions are now exploited. Methods of mine design have been forced to become much more sophisticated and more solidly based on rock mechanics principles.

Under the umbrellas of Economic Regional Development Agreements (ERDAs) between the federal and provincial governments, a number of Mineral Development Agreements (MDAs) were concluded with most of the provinces, commencing in 1984. In general terms, these agreements define the sectors in which projects will be undertaken and the delivery vehicles for the work. In some of the agreements, depending on defined local requirements, provision was made for the inclusion of projects relating to the development of technology to enhance the productivity and competitive position of the minerals industry. Many of these projects may be defined as "mining research".

Before describing these and reporting on the progress to date, however, it is worthwhile to explain the processes by which the projects were conceived. Research, under the MDAs, is not in progress in all of the Canadian provinces in which there is mining activity.

When asked the reasons as to why particular work is being executed in a particular province it is important that one should be aware of the sequence in which the MDA agreements were signed. This, together with a federal role of national coordination and avoidance of duplication provides the answers. When discussing local needs and potential projects in each of the provinces, the work that has been done, and is being done, in the other provinces is always an initial item of consideration. CANMET, because of its national mandate and involvement, is aware of the total research picture. With the amount of interest that is now being generated in mining research, such a national co-ordination of activity is essential.

The most important reason, then, in explaining the pattern which has ensued during the past three years, is that all of the projects, no matter where these are located, have been designed to address defined local needs. In all circumstances this has been done through consultative mechanisms involving the federal and provincial governments and possibly either representatives of provincial mining associations, or of the industry, or both.

As subsequent agreements have been signed, the communications paths have become much better defined. This has been enhanced considerably by the development of provincial mechanisms through which discussions can be formally channelled. The recently-formed research directorate of the Ontario Mining Association (OMA) and the Research Committee of the Saskatchewan Potash Producer's Association (SPPA) are excellent examples of communication channels which have opened within the past year. It is evident that, in those provinces, the mechanisms are now in place to have on-going discussions with industry concerning research needs. The intent is to direct work in such a way that the greatest possible benefits accrue to the industry.

In the other provinces, the paths for discussions with the industry are still evolving. To date, these have been less formal in approach than followed elsewhere and have been conducted with representatives of the industry on an "as required" basis.

After projects have been defined, initiated, and have started to mature, however, the "ad hoc" format of initial talks have matured into a regular reporting structure. In Manitoba, and Ontario, for example, there are now semi-annual meetings with contractors and representatives of the industry to review progress. This same pattern will probably also emerge in Saskatchewan and New Brunswick as mining research projects mature.

In provinces other than those named, the Mineral Development Agreements do not contain a provision for the delivery of mining research. The most important reason for this would probably be that other regional higher-priority research and development needs were selected in the discussions which preceded the agreements.

Most of the mining research which is performed by the federal government is in response to industrial needs. If, after the conclusion of the present mineral development agreements, there remain needs which have not been addressed, some of the reasons can be attributed to problems of communications. The industry is broad and diverse and it is very difficult to obtain consensus; especially regarding needed research.

The paths, and the means of developing these, however, are becoming well-defined as the present agreements mature. It is to be hoped that the entire process will be undertaken from a much higher awareness in the future. In the event that there may be future possibilities for funding, the mining associations would be well-advised to have a "shopping list" of high priority projects, arranged in order of priority for sponsorship and funding, available at "a moment's notice".

The following is a review of the mining research projects presently underway through the federal/provincial MDAs with Manitoba, New Brunswick, Ontario, and Saskatchewan. Nearly all of these are in the areas of rock mechanics and ground control. This, one-dimensional aspect has been of some concern to the writer who has pursued a career as a rock mechanics/ground control specialist.

The reasons, for this, however, are due to the fact that the implementation of rock mechanics and ground control principles and practices is now recognized as having extremely high potential for returns on investment, by the industry. Of all of the parts of the mining production cycle, from exploration to production of metallic end products, it is the process of mining which has received the least attention to date from the research point of view. It may well be, in fact, the only part of the production cycle, in which significant reductions in costs and improvements in profitability can be made. In a threatened industry, the focus of attention on mining methods is logical.

Going one step further, improvements in mining methodology necessitates close examinations of the stability implications. Rock mechanics becomes an essential part of the planning process.

All of the present MDA's were negotiated in the shadow of the recession which began in 1982. Given the focus on the mining process as a potential "cost-reduction centre" it is hardly surprising that, when asked, nearly all mine operators and provincial associations stated that their immediate needs were for practical rock mechanics and ground control.

The following is a summary of the projects now in progress under the supervision of the federal government as the result of those discussions and stated needs:

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

The first of the mineral development agreements involving a mining research component was that which was signed between the federal and Manitoba governments. Nearly all of the mining in that province takes place under hard rock conditions. Thus, the Manitoba projects will produce results which will be potentially applicable to many mines located elsewhere in Canada.

There is a distinct Manitoba flavour to the work, however, insofar as many of the projects are being undertaken in small to medium-sized multi-lensed sulphide orebodies, of which there are several in northern Manitoba. Small mines throughout Canada will probably derive the greatest benefits from this research.

Before describing the federally-delivered projects in Manitoba, it must be mentioned that there are also provincially-delivered projects in progress in that province under the supervision of the provincial Department of Minerals and Energy.

The following descriptions refer only to those projects which are being supervised by the Mining Research Laboratories of CANMET.

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")

The Vertical Block Mining (VBM) method is thought to be a viable alternative to cut-and-fill mining. There are at present, however, no design guidelines which can be used as a means of selection. The objective of the project is to consider all of the design parameters, to monitor in-situ conditions, and to develop a

design manual which can provide a rational basis for mine design. The work is being undertaken by INCO Ltd. at its Thompson operations. The total value of the contract is $362,500.

In the INCO study an assessment will be made of the sizes of production stopes and pillars, the spans, the possible sequences of extraction, the blasting procedures, requirements for ground support, and use of backfill. The intent is that the guidelines should encompass all of the key parameters which are important in the selection of a mining method. An important element of this project is that the work will be done in, and will make special reference to, the particular conditions associated with steeply-dipping orebodies.

Also included in the project is a sub-project which has major implications concerning the health and safety of underground miners. This work is in connection with the development of procedures for blasting down hang-ups in ore passes and chutes. Every miner recognizes that this is one of the most hazardous of all of the tasks in underground mining. The development of better procedures will probably save lives.

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

Increasingly, mining engineers are making use of numerical modelling methods to design underground mine openings and sequences of extraction. To be truly effective such models should, among other features, be able to simulate non-linear and post-failure behaviour of both rock and backfill materials and should be calibrated and verified by reference to actual case history studies.

One of the great benefits of the MDA projects is that their scale, and execution by the industry, makes such practical verifications possible.

In this project, which is the subject of a contract in the amount of $255,500 to INCO Ltd., a numerical model will be produced for the purpose of predicting the ground stresses and deformations induced by mining. In addition to the features mentioned above, the model will also contain provision for major discontinuities in the rock mass and dynamic effects (such as induced by blasting vibrators).

Among the outputs of the project will be software packages accompanied by user's manuals. As with the other MDA projects the intent is to transfer the technology developed to the entire industry as quickly as possible.

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

The use of cemented and consolidated fills in mined out stopes, while now common, has been a feature of Canadian mining practice for only a generation. Previously, unconsolidated alluvial sands, waste rocks, and slags were used. In many areas, depending upon the availability of mill tailings and other considerations, such is still the case.

For such reasons, it is not uncommon for a mining engineer to have to contend with the problem of mining pillars between stopes filled with unconsolidated fill. The alternatives which are available to stabilize such loose fills include pressure grouting and the percolation, by gravity, of cementing mixtures. Stabilization by such methods is necessary for, without it, the dilution by loose fill would soon render further extraction of pillar ores uneconomical.

In this project, which is the subject of a recent contract in the amount of $100,000 to the Hudson Bay Mining and Smelting Company Ltd., a review will be made of the cost effectiveness of the methods which are available for delayed consolidation of

backfills. This will be followed by field trials using preferred methods and the establishment of predictability criteria. There will also be the development of theoretical models and the correlation of field results with these.

The results of the study should permit the recovery of pillars surrounded by unconsolidated fills to be accomplished with greater stability and safety. Additionally, it might be possible to develop a methodology by which the consolidation of backfills could be deferred to a later stage in the mining process, thereby improving cash flows. This would be a very great benefit to smaller operations. Finally, the technology could improve shrinkage stoping methods in which broken waste is placed on top of the ore being drawn down (through lessening dilution).

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

As mentioned previously, mining engineers are now making increased use of numerical modelling methods in the design of underground openings. Additionally, rock mass structural classification systems are also being used to quantify the properties of rock masses - both for predictive purposes and to provide input data for the models referred to. There is a great need to evaluate the rock mass classification systems which are presently available and to compare the actual stability performances of openings versus predictions as mining progresses. The results should permit an enhancement of presently-available predictive tools.

In this project, which is the subject of a $289,100 contract with Sherritt Gordon Mines Ltd., the currently-available classification techniques will be used to forecast ground conditions in the mine. These forecast conditions will be

compared with actual conditions as mining progresses. As the result of these comparisons, the important criteria will be identified and a better predictive methodology will result.

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

Current blasting practices in underground mining are largely based on experience and trial and error. This approach can be costly and can involve risks. With the trend to large-scale methods of mining, the economic consequences of sub-optimal design can be very great. Clearly, there is a need for a rational process of design by which such key parameters as rock mass characteristics, stope geometry, properties of the explosives, timing, methods of initiation, and induced vibrations, can be incorporated as parameters.

In this project, which is being performed by INCO Ltd. under a $260,000 contract with the federal government, a study is being made at a number of test stopes. The field work involves: in-situ testing to determine the dynamic properties of a rockmass; evaluations of rockmass characteristics; trials of test stopes; ground motion monitoring as the result of blasting; analysis of fragmentation achieved; and the development of theoretical and semi-empirical predictive models.

The objectives are to provide guidelines for large-hole underground blasting methods, and to optimize blast performance through improving fragmentation and reducing over-breaking, scaling, and dilution.

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

There is perhaps no other MDA mining research project that has generated more interest from the industry than the current

research on underground communications systems. There is a strong consensus in the industry that voice and data communications systems are needed urgently if progress is to be made towards effective mine information and monitoring systems. The present technology is a bottleneck to further development and, beyond any question, a new approach is needed.

The implications for both worker health and safety and efficiency are simply enormous. An improved voice communications system would permit as-required 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 associated with 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 project, the contractor was to review the state-of-the-art in possible underground mine communications systems, and to select the best of those available for a field trial in a Manitoba mine. The report of the first phase of the work by Falconbridge Ltd. for Sherritt Gordon, was received at the end of 1985. It was in such great demand that many copies were printed and distributed.

Subsequently, the system selected was purchased and installed. The trials under actual operating conditions are now in progress and will be reported shortly. Even at this stage, however, it is clear that there are many opportunities for the development of improved systems.

CANADA/ONTARIO MDA - PROJECTS ON MINE BACKFILL AND ANALYTICAL MODELS

In modern large-scale methods, mining panels are extracted in a pre-determined sequence which permits the controlled adjustment of the pre-mining state of stress. Completed panels are usually filled with backfill in order to provide support. Often, cement is added to the backfill as a means of increasing strength.

Mill tailings, as a material for backfill, has been used in the mines of the Sudbury basin for over 30 years. It was in these same mines that much of the original work was done with cemented backfills. Originally, the intent was to provide a hardened floor in cut-and-fill stopes, on which broken ore could be scraped with minimal resulting dilution.

With the advent of large-scale blasthole methods in the past two decades, however, cement has been added to entire pours of tailings in order to improve the free-standing heights of unsupported fill walls. With the fill unsupported during the mining of contiguous panels, the height at which it will stand undisturbed is of vital importance to mine design. Greater heights permit increased level intervals and, consequently, less development and lower unit costs.

The amount of cement required to provide the strengths desired is a key question. Cement is expensive and the amount consumed in large-scale backfilling operations can be enormous. Any optimization in filling technology can have far-reaching benefits for the industry.

It was for this reason that the focus of mining research under the Canada/Ontario Mineral Development Agreement was placed on mine fill. The industry had identified this as one of the most urgent areas for practical research. CANMET responded by recommending a total of $3.55 Million for commitment mostly to field-scale experiments to be performed

by the industry. Work is now in progress on projects addressing: the comparative properties of various fills; the development of predictive models; and mining strategies. The contracts were initiated in 1986.

At the same time, provision was made to initiate a small laboratory dedicated to studying the engineering and physical properties of fills. Such a highly specialized laboratory, dedicated to the mining industry as a source of technical support, does not yet exist. The laboratory, to be a small highly specialized unit within CANMET's Mining Research Laboratories Division, will be operational in Sudbury, before the end of this year.

All of the projects are now in progress. These are as follows:

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

Mill tailings are emplaced as backfill in the form of a slurry. As a result, the water which was used to transport the solid particles to the stopes being backfilled must be pumped from the mine as the fill consolidates and ages. Cement, added to increase the strength of the fill, is leached away as the water percolates downwards.

The successful use of higher-density paste-type fills would offer a number of improvements to mine operators. First, with much less water being used, there would be significant reductions in pumping costs and cement losses. Second, because of the increased retention of cement and higher density, the fill would attain higher strengths more rapidly. Third, this in turn, would simplify the methods which are used to design the structures used to contain the fills (i.e., bulkheads and fill fences). Fourth, there would be an improvement in the handling of slimes and in costs of clean-up underground.

Two projects, involving alternative technologies are in progress:

(a) At INCO Ltd., in the Sudbury basin, work has been in progress for some time at the Levack Mine, to design a system which will permit the delivery of high-density fills directly through pipelines. A CANMET contract, in the amount of $112,000, is in place to accelerate this work.

The initial results at depths at less than 1,200 feet have been very successful. Consideration is now being given to extending the technology to openings at greater depths.

(b) At Dome Mines Ltd. an alternative approach to the delivery of paste fill is being investigated. Through a CANMET contract, in the amount of $152,580, the company is evaluating the potential use of a device known as the "tailspinner". Operating much like a centrifuge, the tailspinner receives liquid backfills at normal pulp density (about 60% solids by weight). On delivery, the water is spun from the fill and removed. An extruded paste is emplaced.

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

In cut-and-fill mining, the intervening pillars between previously-mined stopes are recovered during secondary extraction. Sill pillars, between the mining blocks and the levels, are recovered during a final, or tertiary, stage. The entire process of extracting all of the ore between levels may involve several years.

During this process, however, mining practices and economic conditions are constantly changing. The results can be great departures from original plans and large variations between the properties of fills in contiguous openings.

In order to provide increased confidence in both design methodology and extractive practices, a project, involving both in-situ monitoring of ground conditions during the extraction of sill pillars and computer modelling for predictive and back-analytical purposes, was initiated with Falconbridge Ltd. The contract, under the Canada/Ontario MDA is valued at $154,720.

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

In the room-and-pillar mines in the near-horizontal tabular uranium deposits of Elliot Lake, backfill has not been used. Until recently, this has not been considered to be necessary, since the vast mined out areas have remained quite stable. Within the past two years, however, there has been much increased rockbursting and failures of the rib pillars in the area near the boundary pillar between the Denison and the Rio Algom mining operations. The area affected has been more-or-less in the centre of the previously mined part of the ore-bearing conglomerate reef.

To study the use of mill tailings backfill as a means of stabilizing an area which is in the process of fracturing, a project, with a contract value of $610,000, was initiated with Denison Mines Ltd. In this research, the stabilities of pillars will be monitored as a selected area is backfilled. Monitoring will involve both stress measurement and microseismic techniques. A microseismic system, belonging to CANMET, has been installed in the designated area of the mine for the purpose of the study.

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

The industry, and particularly the smaller mining operations, are in great need of computer software packages which can be used to improve operating efficiencies and productivities and to reduce

costs. The needs have been expressed to CANMET on many, many occasions.

Originally, during the conception of the Canada/Ontario MDA projects, it was planned to identify a number of specific requirements for software and to sponsor the development of the packages.

At the urging of specialists, however, it was decided that the best, and necessary, first step should be the design of a protocol. Accordingly, a contract, in the amount of $50,000 was signed with Mining Resource Engineering Ltd., of Kingston, Ontario. The firm was charged with the responsibility of determining the computing capabilities and needs of the industry and of recommending specifications which would ensure a high degree of universality of approach over the next few years (i.e., 3 to 5 years).

The project has now been completed and the final report will be available shortly. In summary, UNIX has been selected as the recommended operating system, and Fortran and C as the programming languages.

Depending on the availability of funds, additional work may be initiated towards the development of specific software packages.

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

In spite of the fact that a wide range of materials has been used as backfills in mines (i.e., alluvial sand, waste rock, mill tailings, slags, and mixtures of these), very little is known concerning the relative merits or demerits of these. There is a need to determine the properties of various backfill alternatives and to establish general engineering specifications.

To accomplish this, a contract, in the amount of $470,000 was signed with Falconbridge Ltd. Much of the work is being carried out at the Kidd Creek operations.

In the research, which has just commenced, various types of backfill will be emplaced in openings which have been surrounded by monitoring instrumentation. The results of this large-scale comparative study should permit a quantification of the support characteristics of fills. Further, the relationships between laboratory and field properties, once established, will permit the establishment of specifications.

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

During the past decade, especially, there have been rapid advances in the analytical tools which are available to rock mechanics specialists. Numerical modelling techniques have taken the place of experimental stress analysis and are now used for engineering design purposes.

The computing requirements for the larger models, however, can be far beyond the capabilities of most organizations. For this reason "mine wide" models are very rare and are mostly the property of large international-scale consulting organizations.

There is a need, both to advance the technology which is available and to investigate ways in which it can be transferred to smaller scale computers. By doing so, it would become available to the smaller organizations which do not presently possess the specialized skills necessary.

In order to develop a sophisticated three-dimensional model, applicable on a very broad scale, and suitable for simulating a wide variety of mining conditions, a contract in the amount of $1,000,000 was signed with INCO Ltd. The contractor will not only develop the model but will also calibrate it and refine it by making frequent reference to actual in-situ conditions and measurements.

The project has only just begun and will require several years to complete. The result should be one of the finest numerical models in the world.

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

One of the greatest concerns of any mine operator using mill tailings as a backfilling material relates to its liquefaction potential. Fine-grained materials, with a high moisture content, can liquefy under dynamic loading conditions. In a worst case scenario, a seismic disturbance could cause the fill in a recently-filled stope to liquefy, break the bulkheads due to the resulting sudden increasing pressure, and to flood out into the openings below. The results, as at Belmoral (but with overburden rather than fill) could be catastrophic.

In order to define the engineering parameters involved, and to study such behaviour of fill, and particularly densified fill, a contract in the amount of $125,250, was signed with Dome Mines Ltd.

The results of this research will be very valuable to industry and are keenly awaited.

CANADA/NEW BRUNSWICK MDA - PROJECT ON POTASH MINING

Nearly all of the sectors of the Canadian mining industry with the exception of gold, have suffered terribly from the current depressed metals prices. In New Brunswick, because of a narrower resource base, the problem is especially acute. In the base metals category only Brunswick Mining and Smelting is operating at present.

As elsewhere in the industry, the key to continued operations lies in improved efficiency and productivity. Costs of operations continue to rise while the prices realized for output remain at low values. Long-term viability will depend, in large measure, on a continuing ability to reduce the unit costs of production.

At another location in the province a new potash mine, owned by the Denison Potacan Potash Company is now in production. This occurred concurrently with a decline in the prices paid for potash. The same consideration of improving efficiency and productivity, therefore, also apply.

It was against this background that the conception of mining research projects took place. Unlike the discussions in the other provinces, however, there were two stages in project implementation. In the first, during the original planning cycle, research was to be directed exclusively towards potash. Later, as additional funding became available, the projects were expanded to include metal mining. As will become clear after reading the next section of this paper, on the Canada/Saskatchewan MDA, the reason that the initial focus was on potash was to maintain a momentum of research that had been developed in the mines of Saskatchewan and which was in danger of flagging because of the completion of research projects in that province. The MDA with New Brunswick, and a mutual interest in potash mining technology, offered a timely opportunity for the research thrust to be maintained.

The project now in progress in New Brunswick is:

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

Potash mining in Canada is essentially a "one-pass" type of operation. Rooms are mined in a series of passes using highly mechanized boring machines. The rate of advance is very rapid and total extraction of mineral probably averages about 40%. The intervening pillars between rooms are not mined, nor is backfill used. The present economics of potash mining are said to preclude the use of fill. The extraction ratio is low by design in order to provide long-term stability both of the rooms and of the overlying strata.

In the long-run, however, the low extraction ratio will result in a loss of reserves.

A second problem is that the potash is interbedded with salt. Because of contamination with other minerals this salt is not usable for any purpose. After separation during milling, therefore, it is transported to storage piles on the surface. In the future the ultimate disposal of the waste salt will pose a number of environmental concerns.

The project in New Brunswick was designed to address both of these concerns. Under a $214,740 contract with the federal government the Denison Potacan Potash Company will evaluate the stabilizing effect of waste salt as a backfill in mined openings.

In the first phase of the work, a study is being made of the engineering properties of waste salt backfill, and of the effects of additives on strength. The costs and benefits of alternative stowing procedures are also being assessed. Finally, using numerical methods of stress analysis, determinations are being made of the effects of backfilling upon convergence and the creep of mine openings.

Plans are being made for a field scale demonstration trial, which will form the second phase of the study.

Other possible projects, in the metal mining sector, are now under discussion.

CANADA/SASKATCHEWAN MDA - PROJECTS FOR POTASH MINING

The federally-funded mining research which has taken place in recent years in the Saskatchewan potash mines can be divided into two phases. In the first of these, which preceded the Mineral Development Agreements by about two years (i.e., 1983 to 1985), approximately $443,000 was committed to mining research through the START (Short-Term Assistance for Research and Technology) program. Many of the immediate needs of the industry were perceived as having been met; therefore, when the discussions leading to an MDA took place. As a consequence, the amount allocated through the MDA is much reduced from the previous level.

In a strict sense the purpose of this paper is to review the work in progress under the various federal/provincial MDA agreements. By doing so, however, without reference to the major commitment of funding to the START projects which immediately preceded the MDAs, one could give the wrong impression that a major area of research needs is not being addressed. Thus, for purposes of record, a list of the START mining research projects is given in Table 1. No descriptions are provided in this paper as doing so would involve considerable space. For further details, the reader is referred to the proceedings of a technology transfer seminar which took place, in Saskatoon, in 1984 (1).

The two projects now in progress, which will be described shortly, were implemented after discussions with, and on the recommendations of, the Research Committee of the Saskatchewan Potash Producers' Association (SPPA). During the past year that group has achieved consensus on the needs and priorities for research in the potash mines of their province. It is to be hoped that there will be a third phase of research in the not-too-distant future.

The present projects under the MDA are:

Project: "Research on Microseismic Technology"

The problems of rockbursting have been acute in the hard rock mines of Ontario in recent years. Research has also taken place in Saskatchewan, with a microseismic monitoring system being installed at one of the Potash Corporation of Saskatchewan (PCS) mines.

In this project, which is co-funded by the SPPA, the objectives are to participate in the important microseismic research projects which are currently in progress at three Canadian universities. These address research into low frequency microseismics, geotomography, and acoustic emissions.

The federal contract in support of this work, in the amount of $40,000, is in place with the Potash Corporation of Saskatchewan. As mentioned, this funding is matched by the SPPA.

Project: "Regional Subsidence Related to Potash Mining"

The objectives of this project are to update the analysis methodology applied to subsidence data from the potash mining fields and to improve the capabilities in prediction. Current methods of collecting subsidence data are very labour-intensive

TABLE 1

CANMET/MRL Mining Research Projects Completed in Saskatchewan Under the START Program

1983-1985

Title	Contractor	Value of Contract
Alternatives to Present Potash Mining in Canada	MONENCO	$ 52,040
Assessment of Possible Problems in Regional Mine Stability with Future Mining of Saskatchewan Potash	Potash Corp. of Saskatchewan	$ 89,879
Creep Cell Evaluation and Laboratory Testing of Large Evaporite Samples	Saskatchewan Research Council	$39,938.50
Numerical Modelling Package to Design Underground Openings in Potash	RE/SPEC Ltd.	$ 47,579
Determination of Engineering Properties of Waste Salt for Backfilling Underground Potash Mines	RE/SPEC Ltd.	$ 25,250
Dust Measuring Techniques and Dust Levels in Potash Mines	The Cambrian Eng. Group Ltd.	$ 27,000
Absolute Convergence Measurements in Potash Mine Openings	Cominco, Ltd.	$ 41,717
A Field Test Program to Evaluate the Use of Waste Salt Backfill in Saskatchewan Potash Mines	Central Canada Potash	$ 120,000

and require long traverses over mining areas. Simultaneously, there is a need for a predictive model applied specifically to potash mining.

The work has just commenced, through a federal contract, in the amount of $50,000, with Central Canada Potash. This funding is also matched by the SPPA.

CONCLUSIONS

The entire process of conceiving and implementing mining research projects through the federal/provincial MDA agreements has had a number of significant effects on both the pattern and quality of mining research in Canada. It is to be hoped that the trend will continue for the change in direction has been highly desirable. Some of the key features have been:

1) The projects have, for the most part, been designed through a consultative process involving two levels of government and representatives of either provincial mining associations or industry, or both.

   The process of determining research priorities has improved with each successive agreement. Increasingly, consultations commence earlier and involve more people.

2) Because of this, the work that is initiated is in direct response to the needs of industry. Relevance of the work and applicability of the results is virtually guaranteed.

3) The work itself is mostly being accomplished by industry through government contracts. During the past three years this has meant that the percentage of MRL's responsibilities for extramural research have increased from about 5% to about 50%.

4) Further, the scale of the typical research project has changed. Not so long ago, research contracts of the order of $10,000 to $20,000 were the norm. From an inspection of the projects tested in this paper it can be seen easily that there has also been a tenfold increase in this area! Many of the projects tested are in the vicinity of a quarter to a half of a million dollars each. This year, the first million dollar contract was signed (under the Canada/Ontario MDA), for the development of a large-scale numerical model.

5) Largely as the result of the MDAs, mining research has come out of the laboratories and into the mines. Bench-scale projects have been replaced by full-scale field demonstration projects. The impact of this is bound to be colossal.

6) The consultations involved in designing, implementing, and monitoring of the projects has led to vastly improved communications between government and industry. Communications with industry have generally been good in the past. At present, however, in many areas these are now outstanding.

7) These communications have led to an increased collaboration and partnership in research. This is financial as well as physical. Nearly all of the projects mentioned in this paper involve not only federal funding but also substantial commitments on the parts of the companies involved. "Dollar matching" is common; in many cases companies are contributing substantially more.

8) The MDA agreement discussions have created a new framework within which research needs can be defined and priorities attached to these, and then followed with project implementation. This has instilled confidence and trust in working with government. The MDA process has been spectacularly successful. It is to be hoped that the model will be continued.

REFERENCES

(1) "Seminar on Canadian Potash Mining and Ground Control", Mining Research Laboratories Division Report MRP/MRL 85-1 (INT), January, 1985.