Mineral Development Agreement

Canada–British Columbia 1985–1990

MDA

SUMMARY REPORT

Canada BC

Summary Report

on the

Canada/British Columbia Mineral Development Agreement

(1985 – 1990)

Compiled by Brenda Janke

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FOREWORD

This report summarizes the results of projects carried out under the Canada-British Columbia Mineral Development Agreement (MDA), 1985-1990. This agreement was one of several subsidiary agreements developed under the Canada-British Columbia Economic and Regional Development Agreement (ERDA).

The purpose of the MDA was to coordinate the efforts of Canada and British Columbia to strengthen and diversify the province's minerals industry. Funding of $10 million was provided for the agreement, cost shared equally by the federal and provincial governments. The term of the agreement extended from April 1, 1985 to March 31, 1990.

The activities sponsored under the MDA were grouped into three programs: 1. Promotion of British Columbia Mineral Potential; 2. Financial Assistance for Mine Development; and 3. Management, Public Information and Evaluation. About 80 percent of the total budget was allocated to activities funded under Program 1, 18 percent for Program 2 activities and two percent for Program 3 projects.

A Management Committee appointed by the federal and provincial ministers was responsible for planning and coordinating activities. Implementation of most of the activities was supervised by the British Columbia Ministry of Energy, Mines and Petroleum Resources (BCEMPR). About six percent of funds were directed towards aeromagnetic surveys, which were conducted under the supervision of Energy, Mines and Resources Canada.

There are 130 project summaries presented in this report. Each project is described according to the fiscal year(s) in which it was funded, the amount of MDA funding received, the principal researcher(s), the supervising agency and the area in the province where the research was located. The objectives, and achievements of each project are summarized, as well as an estimate of the impacts generated. A listing of all of the project's outputs, in terms of papers, reports and presentations, is given at the end of each project summary. If the project was cost shared with industry, the industry participants are listed and the total project cost is estimated. Expenditures for the 1990 - 1991 fiscal year are not actual expenditure amounts and are only budgeted figures at this time.

The results summarized in this report indicate that MDA activities have had a significant impact on the mining and exploration industry. The acquired geoscientific data has already led to increased exploration activity and more appropriate targeting of exploration and development programs. A number of potentially significant mineral occurrences have been discovered and documented. As well, the opportunities presented by industrial minerals are now more widely understood and several new prospects are under consideration by industry.

Studies carried out under the market, technical and feasibility sub-component have provided economic and technical data to assist industry and guide government policy. Industry is currently using several of the applications for new techniques and technologies to enhance resource recovery. Significant progress has been made with respect to understanding and developing possible solutions to the environmental problems associated with mining, and in particular for the prevention, treatment, monitoring and control of acid mine drainage.

Infrastructure assessments carried out under the Financial Assistance for Mine Development program have helped to bring some of the province's more remote ore bodies into production. Three of the access roads studied have been constructed - to the Golden Bear, Nickel Plate and Lawyers mines. Two others, the Windy Craggy and Iskut River roads, are currently under review.

Although it is too early to measure all of the impacts generated by the MDA, it is clear from this report that considerable progress has already been made towards strengthening and diversifying the province's minerals industry. The effects will be felt far into the future.

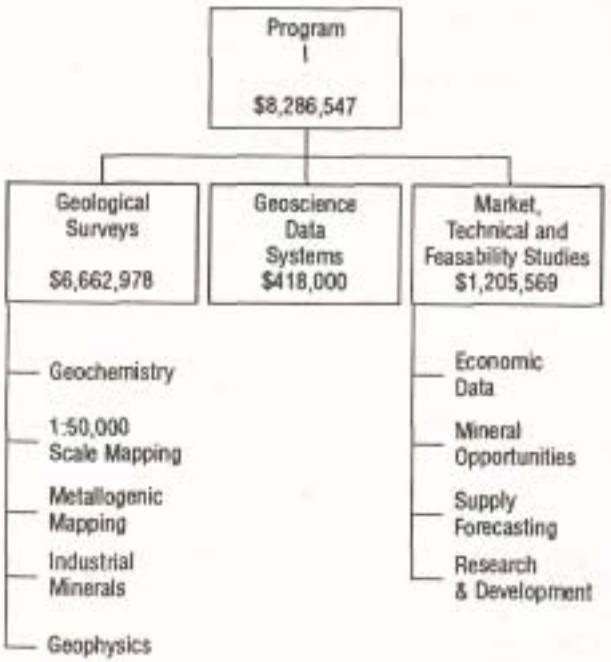
CONTENTS

PROGRAM I

1. Promotion of B.C. Mineral Potential

The purpose of this program was to provide the province's exploration and mining industry with timely geological, market and technology information to enable more appropriate targeting of exploration and development activities leading to the operation of new mines. During the term of the Agreement, expenditures on this Program totalled $8,286,547.

Program 1 consisted of three components: Geological Surveys, Geoscience Data Systems, and Market, Technical and Feasibility Studies. Expenditures on each component were $6,662,978, $418,000 and $1,205,569, respectively.



GEOLOGICAL SURVEYS

This component of Program I was intended to stimulate and focus mineral exploration activity by improving the geoscience database and identifying areas with high potential for minerals of economic interest. Activities included geochemical surveys, 1:50 000 scale geologic mapping, metallogenic mapping, industrial minerals investigations and geophysical surveys.

In the early years of the MDA, most of the major geological survey projects were carried out under contract by specialists in the private sector. In later years, the Geological Survey Branch of the British Columbia Ministry of Energy, Mines and Petroleum Resources (MEMPR) expanded and thereafter Ministry geologists performed much of the work. The aeromagnetic surveys delivered by the Geological Survey of Canada were the only MDA activity carried out and supervised by the federal government.

Most of the geological survey data that was produced under the MDA was made available to the public in a timely manner through Open File maps, reports in the Geological Survey Branch annual publications, geoscience journals and in public workshops and presentations.

GEOCHEMISTRY

During the term of the MDA, three types of geochemistry projects were carried out. MDA expenditures on geochemistry projects amounted to approximately $1,148,000. Most of the funding was directed towards completion of six regional geochemical surveys conducted by the MEMPR.

MDA funding allowed the Ministry to build up a team of geochemists in the province with expertise to manage and deliver the regional geochemical survey (RGS) program based on national standards. British Columbia was the first jurisdiction in Canada to release regional geochemical survey data on floppy diskettes, thereby facilitating use of these data by industry. Several new mineral showings were discovered resulting from follow-up of RGS anomalies. As well, pioneering research conducted under the MDA on moss mat sampling, has demonstrated the effectiveness of this sampling medium for defining both base and precious metal exploration targets.

1:50 000 SCALE MAPPING

Geologic maps are the primary data source for nearly all pure and applied earth science research. These maps are used by scientists, planners, exploration geologists and engineers in the search for energy and mineral resources, in studies of geologic hazards, land use issues, and waste disposal.

Prior to the start of the MDA, small scale (large area, limited detail) geologic maps were available for essentially all of British Columbia. Less than 10% of the province, however, was mapped at the larger scales (1:50 000 or larger) essential for most users of geologic maps. To make matters worse, many of the available small scale maps were obsolete, having been compiled decades ago without the benefit of modern geologic concepts and techniques.

Recognizing the importance and need for large scale up-to-date mapping, the MDA initiated a program of 1:50 000 scale geologic mapping in selected areas of the province. Through this program, regional 1:50 000 scale geologic mapping was demonstrated to be not only viable, but probably the optimum scale to portray geology and mineral potential in British Columbia's mountainous terrain. As well, the early success of MDA projects provided the impetus for the establishment of a 1:50 000 scale mapping program initiated by the Ministry in 1987.

The MDA provided funding for six 1:50 000 scale geological mapping projects. Total MDA expenditures in this sub-component amounted to about $2,718,000. Four of these projects were multi-year investigations conducted north of Bridge River in southwestern British Columbia, in the Smithers-Whitesail Lake area in the west central part of the province, on Vancouver Island and in the Midway-Cassiar area.

The provincial geoscience data base has been expanded as a result of the 1:50 000 scale geologic mapping program. A better understanding and definition of the potential distribution of mineral deposits in the province has been achieved. MDA projects have helped to focus industry attention on areas with greater mineral potential and increase the effectiveness of exploration activities, thereby reducing industry costs. Several mineral discoveries made during the MDA are currently under investigation by industry.

METALLOGENIC MAPPING

Over twenty deposit scale mapping projects throughout the province received MDA funding. As well, support was given to another nineteen projects conducted at the University of British Columbia. Total MDA expenditures in this sub-component were about $1,544,000.

MDA funding expanded the Ministry's established program of mineral deposit studies. The results of many of the smaller MDA projects were incorporated into subsequent work done by the Geological Survey Branch. In some cases, the initial MDA funded work led the way for future projects.

The five coal projects carried out under the metallogenic mapping component have increased awareness of the potential metallurgical, thermal and coalbed methane resources in southeastern and northeastern British Columbia. Future industry exploration and development activities will be guided by the new information.

The nine MDA projects that were focused on gold have provided a better understanding of provincial gold resources. The potential of gold bearing skarns was recognized and several companies are currently exploring gold skarns in south central and northwestern British Columbia and on Vancouver Island. An extensive study of the Quesnel mineral belt has led to a more effective assessment of mineral claims in the region. The other regional studies of gold occurrences have focused industry attention on under explored areas with high precious metal potential elsewhere in the province.

Seven other MDA metallogenic mapping studies resulted in an improved understanding of the different types of mineral deposits hosted in the province's diverse geologic environment. The largest project was a four year investigation of Alaskan mafic and ultramafic rocks to evaluate their potential as sources of platinum group elements. Specific targets were defined which are currently undergoing further evaluation by industry. Another major project involved the mineral evaluation of a proposed park in the Chilko Lake area. This project identified zones of high mineral potential, some of which have been staked by industry, and provided valuable information for use in a provincial park assessment.

Nineteen studies were undertaken by faculty and staff at the University of British Columbia. These projects led to a better understanding of the geology and mineral potential of the province and complemented research by government and industry. In addition, this work contributed to the education of the next generation of geoscientists.

INDUSTRIAL MINERALS

MDA expenditures on twelve industrial mineral projects amounted to about $627,000. These projects compiled an inventory of provincial industrial minerals with development potential. The first provincial scale maps of industrial minerals known occurrences were produced. Provincial resources of dimension stone, limestone and dolomite, peat, olivine, nepheline syenite, feldspar, carbonatites, garnet, silica, talc, zeolites, fluorspar, magnesite and phosphate were documented.

The MDA projects have increased awareness of provincial industrial minerals, which should contribute towards a more diversified mining industry in the future. Significant industry interest was generated in the potential of provincial industrial minerals and many private sector companies began or intensified exploration activities as a result of project findings. Further, plans are currently underway by private companies to develop provincial garnet and talc resources.

GEOPHYSICS

Regional aeromagnetic surveys were conducted in three areas of British Columbia by the Geological Survey of Canada. Total expenditures in this sub-component amounted to $625,000. The data collected will aid in geological mapping and interpretations.

1.1 Geological Surveys

1.1.1 Geochemistry

Geochemical Surveys - the collection, preparation, and analysis for a suite of elements of geological materials such as rock, soil, stream and lake sediments, water, and vegetation to identify variations in element distribution that may be interpreted as indicating areas of enhanced mineral potential.

Project name	GEOCHEMICAL INTERPRETATION
MDA expenditures	$102,503 (1986-1987)
Principal researcher(s)	P. MATYSEK AND J. GRAVEL
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	PROVINCE-WIDE

OBJECTIVES To enhance the mineral industry's knowledge and use of exploration geochemistry in British Columbia and thereby improve the probability of discovering new ore deposits. This project intended to conduct research into geochemical sampling, analysis and interpretation methods.

ACHIEVEMENTS As a result of this project, the British Columbia Geological Survey Branch (GSB) was one of the first in Canada to release regional geochemical survey (RGS) data in a digital format on 5 1/4" floppy diskettes. The data are accessible by personal computer and can be manipulated by various commercial statistical and plotting programs. Sales of these digital packages indicate there is a growing use by both individuals and major exploration firms of this type of data and technology.

Pioneering research on moss-mat sediment as an alternative stream sampling medium and it's incorporation into the Regional Geochemical Surveys was initiated by this project and has since stimulated the exploration community to follow suit. The GSB has become a source of expert information on the sampling, handling and interpretation of moss-mat surveys.

IMPACT Digital RGS data packages have increased user flexibility, which has resulted in a more sophisticated level of geological interpretation. To date over 1000 digital data packages have been sold.

Several new mineral showings can be directly accredited to the use of moss-mat sediment in stream surveys as reported by individuals and private firms. Old mining camps are being rejuvenated as exploration firms re-assess their mineral potential using moss-mat sediment surveys. The following are but a few of the companies that have recently incorporated moss-mat sampling into their exploration programs: Battle Mountain (Canada) Incorporated, BP Canada Incorporated, Cominco Limited, Placer Dome Incorporated, and Teck Corporation.

OUTPUTS

Fieldwork Articles

Matysek, P.F.(1986): A New Look for Regional Geochemical Survey Data, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 387-394.

Matysek, P.F. and Saxby, D.W. (1986): Comparative Study of Reconnaissance Stream Sediment Sampling Techniques for Gold Fieldwork (93L), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 395-400.

Matysek, P.F. and Day, S.J. (1987): Geochemical Orientation Studies Northern Vancouver Island Fieldwork and Preliminary Results, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, pages 493-503

Day, S.J., Matysek, P.F. and Johnson, W.M. (1987): The Regional Geochemical Survey Evaluation of an ICP-ES Package, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, pages 503-508.

Day, S.J. and Matysek, P.F. (1988): Using the Regional Geochemical Survey Database Examples from the 1988 Release (104B, F, G. & K), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 593-602.

Other Publications

Matysek, P.F. Day, J.S. and Gravel, J.L. (1987): British Columbia Profile; *Association of Exploration Geochemists*, Explore Newsletter, Vol 61, Oct. 1987, pages 1-3.

Talks

Matysek, P.F.(1989): "Using the Regional Geochemical Survey Database"; Kootenay Exploration Meeting, Eastern Chamber of Mines, Nelson, British Columbia, April 12-14, 1989.

Matysek, P.F.(1989): "Quality Control of External Laboratory Contractors at the British Columbia Geological Survey Branch"; Canadian Institution of Chemistry, Victoria, British Columbia, June 6, 1989.

Gravel, J.L.(1989): "Exploration Geochemistry for the Prospector"; Kootenay Exploration Meeting - Prospector's Workshop, Eastern Chamber of Mines, Nelson, British Columbia, April 12-14, 1989.

Gravel, J.L.(1989): "Sicker Volcanics in the RGS: Workshop on Sicker Volcanics", Ministry of Energy, Mines and Petroleum Resources, Nanaimo, British Columbia, October 15-16, 1989.

Gravel, J.L.(1990): "Advances in Moss Mat Research"; Vancouver Geochemical Group, Vancouver, British Columbia, March 24, 1990.

Gravel, J.L.(1990): "Moss Mat Nature's Little Sluice Box"; Canadian Institution of Chemistry, Victoria, British Columbia, April 21, 1990.

Matysek, P.F.(1990): "The Golden Fleece and Gold Exploration in British Columbia; Renaissance of an Old Prospecting Tool"; Prospectors and Developers Association Meeting, Toronto, Ontario, March 13, 1990.

Project name	REGIONAL GEOCHEMICAL SURVEYS
MDA expenditures	$867,539 (1986-1990) $128,000 (Budgeted, 1991)
Principal researcher(s)	P. MATYSEK, J. GRAVEL, W. JOHNSON, S. ZASTAVNIKOVICH, A.J. BORONOWSKI, S. DAY AND W. JACKAMAN
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Other participating agencies	GEOLOGICAL SURVEY OF CANADA
Project location	1986 PRINCE GEORGE AREA 1987 CENTRAL B.C. 1988 NORTHWEST B.C. 1989 NORTHERN VANCOUVER ISLAND 1990 SOUTHERN VANCOUVER ISLAND 1991 SOUTHEAST B.C.

OBJECTIVES To stimulate exploration leading to the discovery of new mineral deposits by undertaking regional geochemical surveys (RGS) in remote and underexplored areas of British Columbia. This project intended to conduct systematic sampling of stream sediment and water at a reconnaissance scale (1 site/10 km^2) over large areas using nationally established methods and standards. The resulting database would be important to the exploration industry for defining regions of high mineral potential. Sediment samples were to be analyzed for gold and 21 other elements. In addition, the database would provide useful information for environmental, land use assessment and health studies.

ACHIEVEMENTS Since 1976, 40 1:250 000 scale NTS map sheets (approximately 50% of British Columbia) have been surveyed from which roughly 39 700 sites have been sampled for either stream, moss-mat or lake sediment and stream water. Partial funding through the Mineral Development Agreement assisted the surveying of 18 map sheets from which approximately 12 500 samples were collected.

The Geological Survey Branch developed the in-house resources (personnel and computer) to generate all Open Files to ensure timely release of RGS data. Innovations in program design, content and presentation were introduced to increase both information content and ease of use. Developments included the use of moss-mat sediment as a primary sample media, new field data collection techniques, in-house computer programs for quality control of analytical data, statistical interpretation techniques to aid anomaly definition and down sizing of element plots that are collated into a map booklet. Also, regional geochemical data were continued to be made available on 5 1/4" floppy diskettes.

IMPACT On average, for recent releases (1987-1990), 100 data and map packages were sold on release day. A production run of 210 packages was generally sold out within the first year.

A claim staking review process initiated in 1989 revealed a 20 to 25% increase in the number of claims held on Northern Vancouver Island which can be directly related to the release of British Columbia RGS Open Files. Explorationists within the industry have reported several new important mineral showings which were discovered on northern Vancouver Island resulting from follow-up of RGS anomalies. Consolidated Paytel Limited, Placer Dome Incorporated and Transtel Communications Corporation are a few of the companies whose exploration work has been influenced by the geochemical survey data.

In addition, RGS innovations in sampling, analytical and interpretation methods are being adopted by the industry thus advancing the science of geochemistry in British Columbia.

Regional Geochemical Sampling for 23 elements has helped industry define exploration targets.

OUTPUTS

Fieldwork Articles

Boronowski, A.J. and Johnson, W.M. (1985): Regional Geochemical Surveys: RGS 13 - Prince George (93G/W 1/2) and McBride (93H/E 1/2); RGS 14 - McLeod Lake (93J); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1985, Paper 1986-1, page 113.

Zastavnikovich, S. and Johnson, W.M. (1986): Regional Geochemical Surveys RGS 16 - Whitesail Lake 93E and RGS 17 - Smithers 93L West-Central British Columbia; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Field work 1986, Paper 1987-1, pages 411-412.

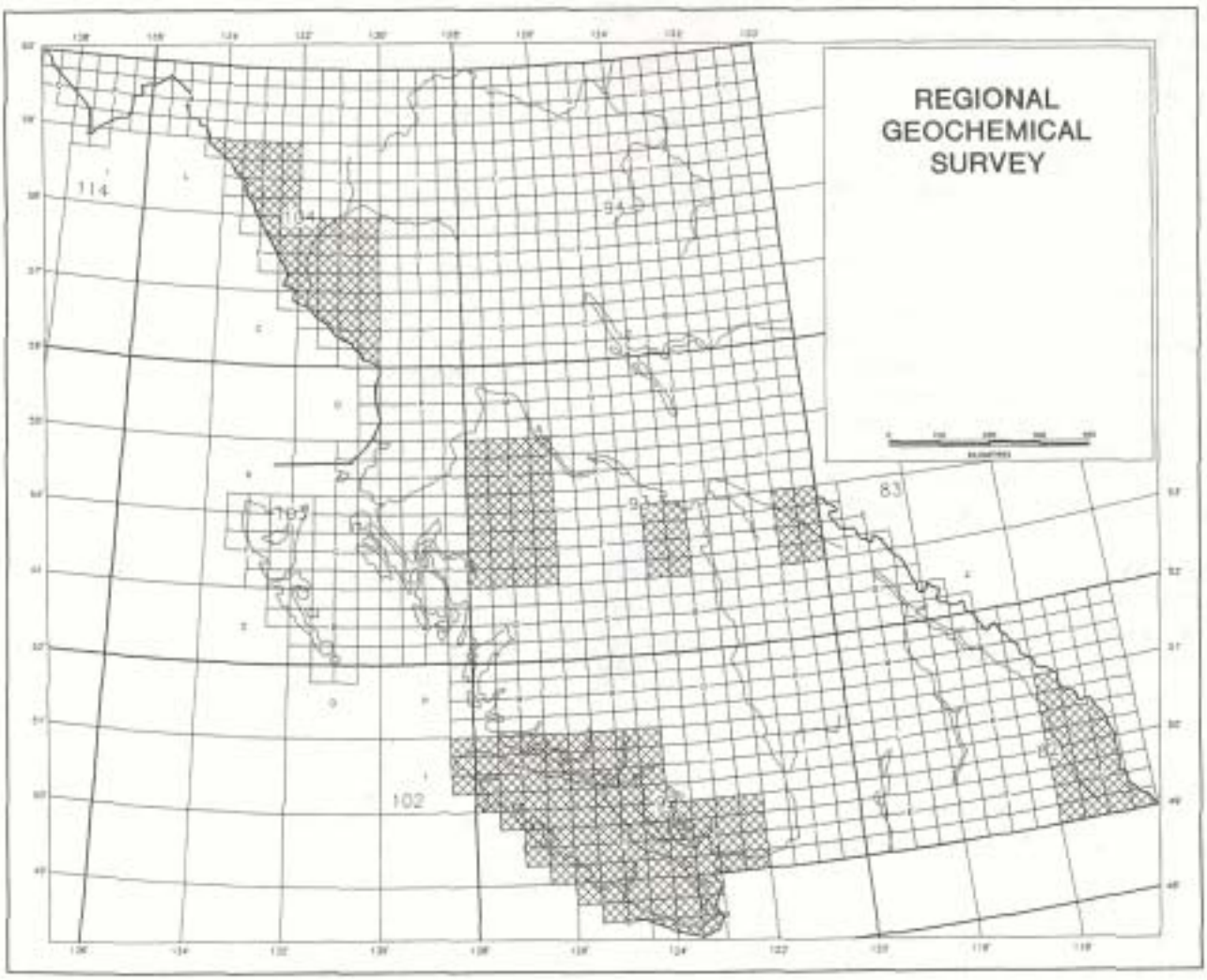
Faulkner, E.L. (1986): British Columbia Regional Geochemical Survey Release - An Assessment (93G, 93H & 93J), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 385-386.

Gravel, J.L. and Matysek, P.F. (1987): Regional Geochemical Surveys RGS 18 - Iskut River (104B); RGS 19 - Sumdum (104F) and Telegraph Creek (104G); RGS 20 - Tulsequah (104K); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, pages 489-492.

Matysek, P.F. (1987): Applied Geochemistry Subsection - Overview of the First Two Years; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, pages 481 488.

Matysek, P.F., Day, S.J. and Gravel, J.L. (1988): Applied Geochemistry Subsection; Highlights of 1988 Activities; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 579-583.

Gravel, J.L. and Matysek, P.F. (1988): 1988 Regional Geochemical Survey, Northern Vancouver Island and Adjacent Mainland (92E, 92K, 92L & 102I); *British Co-*



lumbia Ministry of Energy, Mines and Petroleum Resources, Geological Field work 1988, Paper 1989-1, pages 585-591.

Gravel, J.L., Jackaman, W. and Matysek, P.F. (1989): 1989 Regional Geochemical Survey, Southern Vancouver Island and Lower Mainland (92B, 92C, 92F & 92G); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1990-1, pages 503-510.

Open Files

RGS 13 - Prince George (93G/W 1/2)
RGS 14 - McBride (93H/W 1/2)
RGS 15 - McLeod Lake (93J)
RGS 16 - Whitesail Lake (93E)
RGS 17 - Smithers (93L)
RGS 18 - Iskut River (104B)
RGS 19 - Sumdum (104F) and Telegraph Creek (104G)
RGS 20 - Tulsequah (104K)
RGS 21 - Nootka Sound (92E)
RGS 22 - Bute Inlet (92K)
RGS 23 - Alert Bay (92L) and Cape Scott (102I)
RGS 24 - Victoria (92B) and Cape Flattery (92C)
RGS 25 - Alberni (92F)
RGS 26 - Vancouver (92G)

Papers

Lefebure, D.V. and Gunning, M.H. (1987): Regional Geochemical Stream Sediment Survey Results for Smithers (93L) and Whitesail Lake (93E) Map Sheets; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Exploration in British Columbia 1987, pages 127-148.

Talks

Matysek, P.F.(1988): "Applied Geochemistry Breaking New Ground"; Annual 1988 Cordilleran Roundup, Vancouver, British Columbia, February 6, 1988.

Matysek, P.F., Gravel, J.L. and Day. S.J.(1988): "Review of Applied Geochemistry Programs 1987"; Vancouver Geochemical Group, Vancouver, British Columbia, April 19, 1988.

Matysek, P.F., Gravel, J.L. and Day. S.J.(1989): "Review of Applied Geochemistry Programs 1988"; Vancouver Geochemical Group, Vancouver, British Columbia, February 21, 1989.

Matysek, P.F.(1989): "Introduction to Regional Geochemical Survey Data for Northern Vancouver Island"; Campbell River, British Columbia, June 20, 1989.

Gravel, J.L.(1990): "Introduction to Regional Geochemical Survey Data for Southern Vancouver Island", Nanaimo, British Columbia, July 4, 1990.

Project name	ANALYSIS OF ARCHIVED RGS SAMPLES
MDA expenditures	$49,998 (1989)
Principal researcher(s)	P. MATYSEK, W. JACKAMAN AND S. FEULGEN
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Other participating agencies	GEOLOGICAL SURVEY OF CANADA
Project location	SOUTH CENTRAL, CENTRAL & NORTHWEST B.C.

OBJECTIVES To re-kindle exploration activity by releasing new analytical data for archived sediment samples collected on previous Regional Geochemical Surveys. Concentrations of gold plus 33 other elements including the rare earths were to be determined by neutron activation analysis. The project intended for these new data, in combination with advances in data presentation and statistical interpretation, to highlight subtle mineral trends which had escaped previous detection and to provide a new database with useful information for environmental, land use assessment and health studies.

ACHIEVEMENTS The Mineral Development Agreement funded in part the analysis of 24 972 samples from 21 map sheets.

Archive analysis data from the Nelson and Lardeau areas were compiled with original data to produce the Purcell Wilderness Conservancy geochemistry study which was released as an Open File in February 1990.

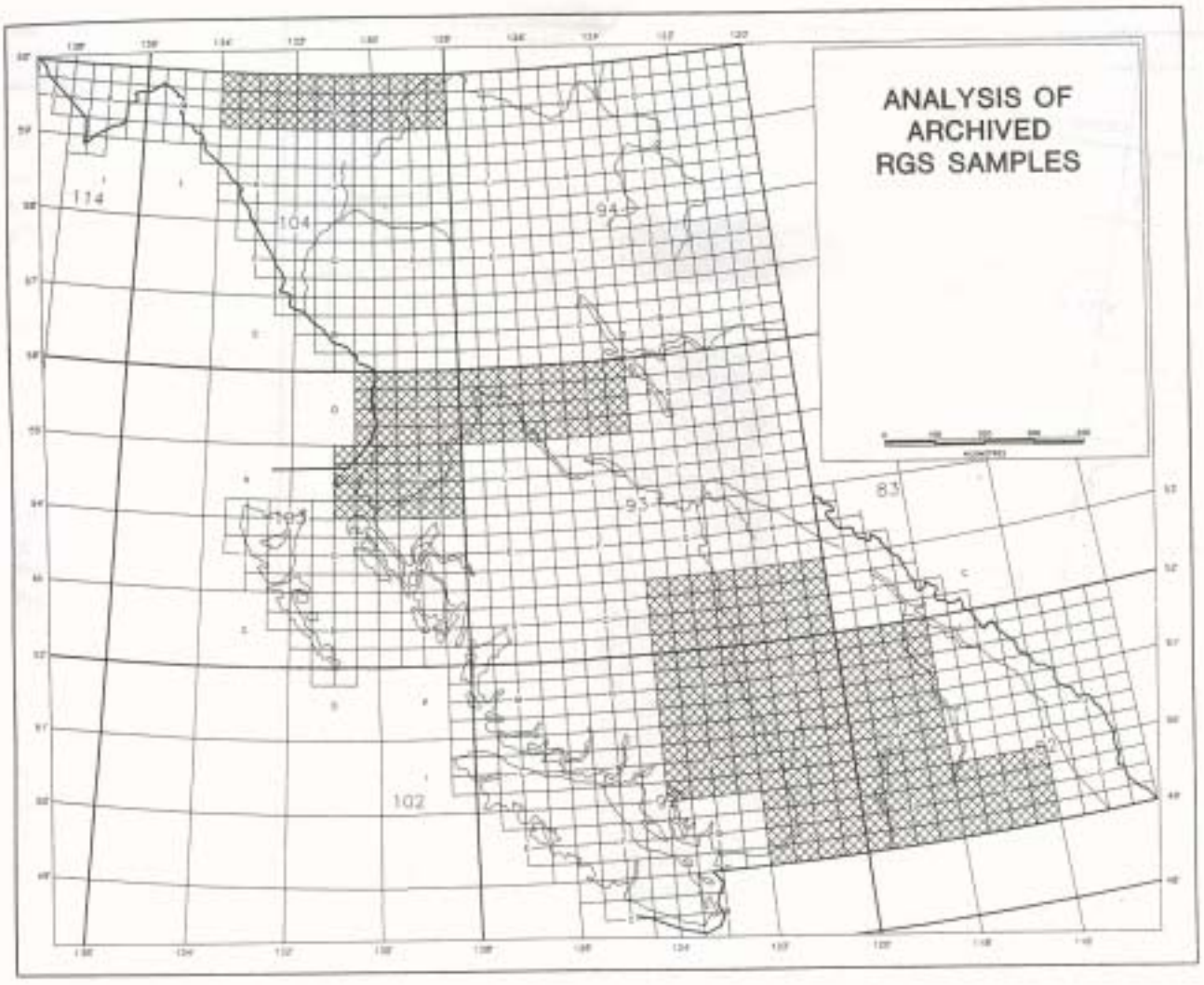
IMPACT The initial release of archived samples analytical data comprising map sheets for the Penticton, Nelson, Lardeau and Vernon areas is tentatively scheduled for Spring 1991. Response is anticipated to be at least comparable to earlier RGS releases which generally saw release day sales of approximately 100 data and map packages and a flurry of pre- and post- release staking activity.

The initial run of 50 data and map packages for the Purcell Wilderness Conservancy Study were sold out and a second run has been completed.

OUTPUTS

Open Files

Matysek, P.F., McLaren, G.P., Jackaman, W., Stewart, G.G. (1990): Stream Sediment Geochemistry of the Purcell Wilderness Conservancy Study Area (NTS 82F/15, 16 and 82K/1, 2, 7 & 8), British Columbia Ministry of Energy, Mines and Petroleum Resources, Open File 1990-11.


ANALYSIS OF
ARCHIVED
RGS SAMPLES
114
104
94
93
83
102

1.1.2 1:50 000 Mapping

1:50 000 Scale Geological Mapping - the identification, within a specific geographical area, of the bedrock types, their origins, their spatial and chronological relationships and the setting of known mineral occurrences to provide a geological data base for resource assessment, and to define broad areas of enhanced mineral potential.

Project name	GATAGA
MDA expenditures	$49,318 (1986-1987)
Principal researcher(s)	K. MCCLAY
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Other participating agencies	GEOLOGICAL SURVEY OF CANADA
Project location	NORTHEAST B.C.

OBJECTIVES To assist industry in the focus of their exploration activity in the Gataga area of northeastern British Columbia by producing a model of the structural and sedimentological evolution of the district.

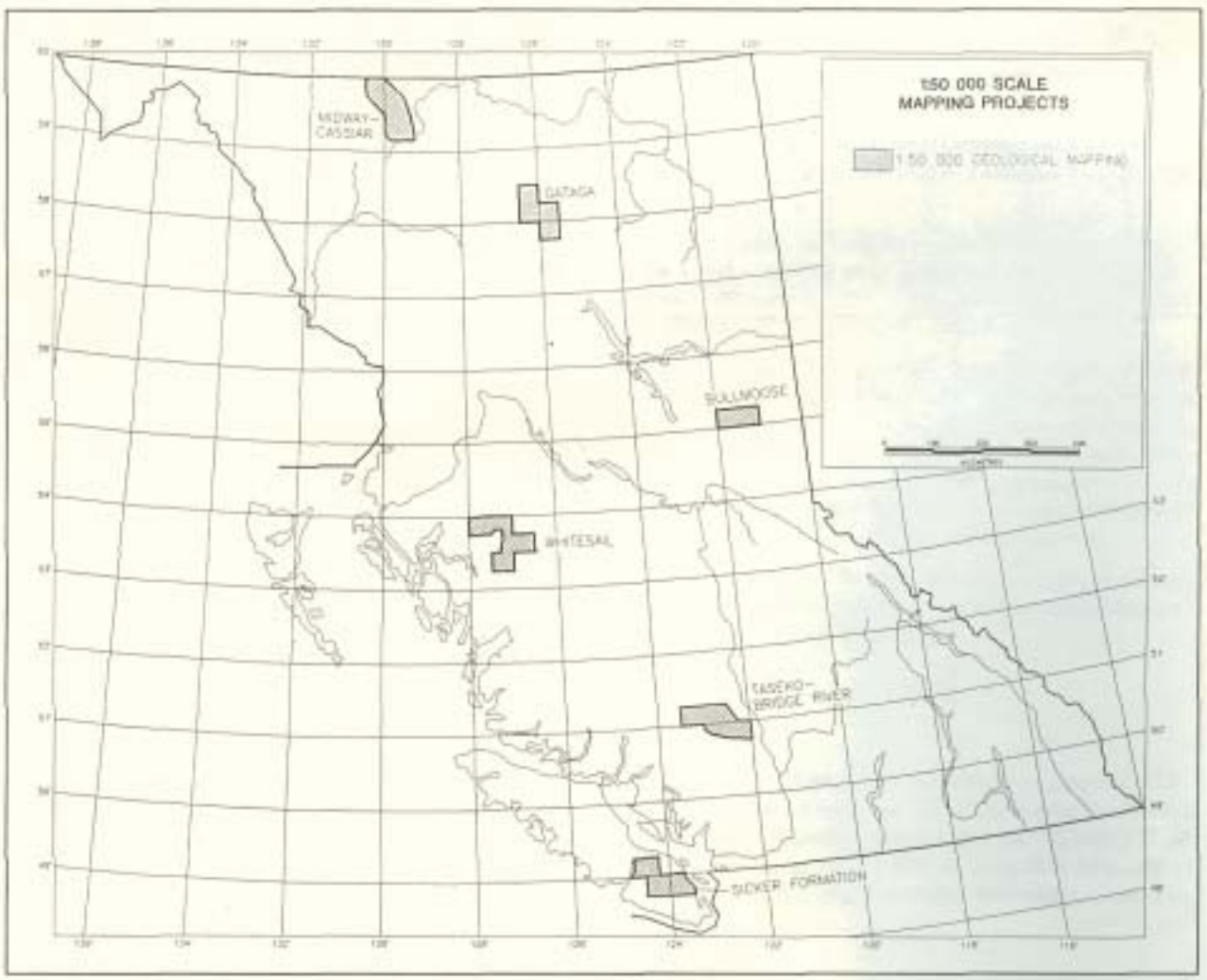
ACHIEVEMENTS Four 1:50 000 scale maps were produced which detail the geology in the vicinity of the Driftpile sedimentary-exhalative (SEDEX) Camp. This work has contributed to a better understanding of the stratigraphic and structural setting of the deposits.

IMPACT The maps have not yet been published. Future exploration work will be guided by the new maps when they are made available.

OUTPUTS

Fieldwork Articles

McClay, K.R. and Insley, M.W. (1985): Structure and Mineralization of the Driftpile Creek Area, Northeastern British Columbia (94E/16, 94F/14, 94K/4, &



94L/1); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1985, Paper 1986-1, pages 343-350.

McClay, K.R., Insley, M.W., Way, N.A. and Anderton, R. (1986): Stratigraphy and Tectonics of the Gataga Area, Northeastern British Columbia (94E/16, 94F/14, 94K/4, 94L/1, 94L/7, & 94L/8); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 193-200.

Papers

McClay, K.R. (1989): Inversion of the Kechika Trough, Northwestern British Columbia, Canada. *Inversion Tectonics*, Special Publication of the Geological Society of London, 1989.

Project name	SICKER
MDA Expenditures	$455,410 (1987-1990)
Principal researcher(s)	N. MASSEY
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	SOUTHERN VANCOUVER ISLAND

OBJECTIVES To guide industry exploration in the Sicker Group of rocks on southern Vancouver Island by providing a detailed analysis of the area's stratigraphy, structure and by metallotect definition. This objective was to be achieved through 1:50 000 scale geological mapping and geochemical surveying of the area and by studying the extent of polymetallic sulphide deposits and their similarity to Westmin Resource's Buttle Lake deposits.

ACHIEVEMENTS Three 1:50 000 scale geological maps were produced which covered the Cowichan Uplift area of southern Vancouver Island. This mapping has led to an improved understanding and redefinition of the stratigraphy of the Paleozoic rocks, which in turn has resulted in better definition of the potential distribution of base metal and other mineral deposits. Major contractional faults of Tertiary age were identified and mapped throughout the uplift. It was discovered that these faults have had a profound effect on the distribution of rocks and mineralization, as well as themselves being conduits for gold-bearing fluids. Studies of the geochemistry of the volcanic rocks of the area are proceeding and will result in a model of the development of the Paleozoic island arc and subsequent igneous events.

IMPACT Extensive private sector exploration of the Paleozoic rocks of the Cowichan uplift took place prior to and during the project. Initial targets were volcanogenic base-metal massive sulphides similar to the Westmin's Buttle Lake deposits. Work has since expanded to encompass the whole range of diverse mineral deposits in the area, particularly those that are gold-bearing. This project has helped to focus the attention of explorationists on other areas of southern Vancouver Island, especially in areas underlain by similar Sicker Group volcanic rocks.

OUTPUTS

Fieldwork Articles

Massey, N.W.D. and Friday, S.J. (1986): Geology of the Cowichan Lake Area, Vancouver Island (92C/16); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 223-229.

Massey, N.W.D. and Friday, S.J. (1987): Geology of the Chemainus River-Duncan Area, Vancouver Island (92C/16; 92B/13), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, pages 81-92.

Massey, N.W.D. and Friday, S.J. (1988): Geology of the Alberni - Nanaimo Lakes Area, Vancouver Island (92F/1W, 92F/2E and part of 92F/7), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, 1989-1, pages 61-74.

Open Files

Massey, N.W.D., Friday, S.T., Tercier, P. and Rublee, V.J. (1987): Geology of the Cowichan Lake Area (92C/16), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1987-2.

Massey, N.W.D., Friday, S.J., Tercier, P.E., and Potter, T.E. (1988): Geology of the Chemainus River and Duncan Area (92C/16E, 92B/13), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1988-8.

Massey, N.W.D., Riddell, J.M. & Dumais, S.B. (1989): Geology of the Port Alberni-Nanaimo Lakes Area (92F/1W, 2E; and part of 7E), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1989-6.

Papers

Massey, N.W.D., Schroeter, T.G. & McMillan, W.J. (1987): Debbie, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Exploration in British Columbia 1987, pages B28-34.

Massey, N.W.D. & Day, S.J.(1988): Moss-mat Stream Sediment Sampling in the Alberni-Nanaimo Lakes Area (92F/1W, 2E and part of 7E), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Exploration in British Columbia 1988, pages B55-62.

Abstracts

Massey, N.W.D., Friday, S.J. & Sutherland Brown, A. (1989): Paleozoic Stratigraphy of the Cowichan Uplift, South Vancouver Island, and Controls on the Distribution of Mineralization, *Geological Society of America, Abstracts with Programs*, Volume 21, page 112.

Talks

Presentations were made at the following:

- University of British Columbia Geology Department, "Geology of the Cowichan Lake Area," Vancouver, British Columbia, March 1987.
- Cordilleran Roundup, "The Stratigraphy and Structure of the Cowichan Uplift, Vancouver Island, and Relations to Mineral Deposits," Vancouver, British Columbia, February 1988.
- University of Victoria Geography Department, "The Geology of Southern Vancouver Island," Victoria, British Columbia, April 1988.
- Geological Society of America, Cordilleran/Rocky Mountain Sections Meeting, Spokane, Washington, May 1989.

Workshops

An informal workshop was presented to industry respresentatives on the Sicker Group geology and mineral deposits in Ladysmith, British Columbia, August 1988.

Wilton, H.P., Pfuetzenreuter, S.N. & Massey, N.W.D. (1989): *Sicker Group Workshop*. Included a two-day fieldtrip before the workshop to the Cowichan uplift area led by N.W.D. Massey. October 1989.

Project name	TASEKO-BRIDGE RIVER
MDA expenditures	**$637,115 (1987-1990)**
	46,500 (Budgeted, 1991)
Principal researcher(s)	P. SCHIARIZZA, R.G. GABA AND J.K. GLOVER
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	SOUTHWEST B.C.

OBJECTIVES To encourage mineral exploration in the Taseko-Bridge River area of southwestern British Columbia by providing a geological framework for known mineral occurrences, alteration zones and geochemical anomalies. This objective was to be achieved through 1:50 000 scale geological mapping, lithogeochemistry and moss mat geochemistry. The project intended to produce an assessment of the overall mineral resource potential of the area, which would be useful for future regional and site specific studies.

ACHIEVEMENTS Four 1:50 000 and two 1:20 000 scale geological maps were produced, which have contributed to a better understanding of the definition, distribution, and stratigraphic and structural relationships of late Paleozoic through Tertiary rock units. A better understanding was also developed of the structural/plutonic controls of metallic mineral occurrences, which include porphyry-style copper-molybdenum, mesothermal gold-quartz veins, auriferous polymetallic veins, stibnite veins, scheelite veins, and cinnabar veins and disseminations. These metallic mineral concentrations, formed over a protracted interval during mid-Cretaceous to mid-Tertiary time, were found to be coincident with several pulses of igneous activity within a changing structural regime that generated contractional, strike-slip and extensional faults.

IMPACT Two specific discoveries made by the project are known to have prompted immediate action by explorationists: 1) The Pat claims were staked by Esso Minerals in 1987 after assays returning 331 to 377 ppm silver were reported from samples collected in 1986 along the margin of the Warner Lake stock. 2) MacNeill International Industries Incorporated implemented a $250,000 diamond drilling program in the fall of 1989, after a project member discovered disseminated molybdenite and auriferous quartz veins on their Cub 200 claim earlier that summer. In addition, recent exploration activity elsewhere in the area has been concentrated in areas shown as favourable on geology and mineral potential maps produced by the project.

OUTPUTS

Fieldwork Articles

Glover, J.K. and Schiarizza, P. (1986): Geology and Mineral Potential of the Warner Pass Map Sheet (92O/3); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 157-169.

Payne, D.F. and Russell, J.K. (1987): Geology of the Mount Sheba Igneous Complex (92O/03), University of British Columbia and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, page 125-130.

Glover, J.K., Schiarizza, P. and Garver, J.I. (1987): Geology of the Noaxe Creek Map Area (92O/2), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, pages 105-123.

MDA mapping projects have helped industry meet the challenges of exploring in B.C.'s mountainous terrain.

Schiarizza, P., Gaba, R.G., Glover, J.K. and Garver, J.I. (1988): Geology and Mineral Occurrences of the Tyaughton Creek Area (92O/2; 92J/15 & 16), *British Columbia Ministry of Energy, Mines and Petroleum Resources* and the University of Washington, Geological Fieldwork 1988, Paper 1989-1, pages 115-130.

Garver, J.I., Schiarizza, P. and Gaba, R.G. (1988): Stratigraphy and Structure of the Eldorado Mountain Area, Chilcotin Ranges, Southwestern British Columbia (92O/2; 92J/15), *British Columbia Ministry of Energy, Mines and Petroleum Resources* and the University of Washington, Geological Fieldwork 1988, Paper 1989-1, pages 131-143.

Archibald, D.A., Glover, J.K. and Schiarizza, P. (1988): Preliminary Report on $^{40}AR/^{39}Ar$ Geochronology of the Warner Pass, Noaxe Creek and Bridge River Map Areas (92O/3 & 2; 92J/16), Queen's University and the *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 145-151.

Schiarizza, P., Gaba, R.G., Coleman, M., Garver, J.I. and Glover, J.K. (1989): Geology and Mineral Occurrences of the Yalakom River area (92J/15, 16; 92O/1, 2); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1989, Paper 1990-1, pages 53-72.

Gaba, R.G. (1989): Stockwork Molybdenite in the Mission Ridge Pluton: A New Exploration Target in the Bridge River Mining Camp (92J/16); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1989, Paper 1990-1, pages 279-285.

Archibald, D.A., Schiarizza, P. and Garver, J.I. (1989): $^{40}Ar/^{39}Ar$ Dating and the Timing of Deformation and Metamorphism in the Bridge River Terrane, Southwestern British Columbia (92O/2; 92J/15); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1990-1, pages 45-51.

Calon, T.J., Malpas, J.G. and Macdonald, R. (1989): The Anatomy of the Shulaps Ophiolite; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1990-1, pages 375-386.

Open Files

Glover, J.K., Schiarizza, P., Umhoefer, P.S. and Garver, J. (1987): Geology and Mineral Potential of the Warner Pass Map Sheet (92O/3), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1987-3.

Glover, J.K., Schiarizza, P., and Garver, J.I. (1988): Geology of the Noaxe Creek Map Area (92O/2), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1988-9.

Umhoefer, P.J., Garver, J.I. and Tipper, H.W. (1988): Geology of the Relay Mountain Area (92O/2, 3); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1988-16.

Garver, J., et al. (1989): Geology of Eldorado Mountain Area (92J/15, 92O/2), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1989-3.

Schiarizza, P., et al. (1989): Geology and Mineral Potential of the Tyaughton Creek Area (92J/15, 16; 92O/2), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1989-4.

Schiarizza, P., Gaba, R.G., Coleman, M., Glover, J.K., Macdonald, R., Calon, T., Malpas, J., Garver, J.I. and Archibald, D.A. (1990): Geology and Mineral Potential of the Yalakom River area (92J/15, 16; 92O/1, 2); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1990-10.

Abstracts

Umhoefer, P.J., Garver, J.I., Glover, J.K. and Schiarizza, P. (1988): Geology of the Tyaughton Basin, Southern Taseko Lakes Map Area, British Columbia: Part of the Boundary between the Insular and Intermontane Superterranes; *Geological Society of America, Cordilleran Section Annual Meeting*, Las Vegas, Nevada, page 238.

Umhoefer, P.J., Garver, J.I., Schiarizza, P. and Glover, J.K. (1989): The Late Cretaceous to Early Tertiary Yalakom Fault System, Southwestern British Columbia; *Geological Society of America, Cordilleran/Rocky Mountain Sections Annual Meeting*, Spokane, Washington, May 1989, page 152.

Garver, J.I., Till, A.B., Armstrong, R.L. and Schiarizza, P. (1989): Permo-Triassic Blueschist in the Bridge River Complex, Southern British Columbia"; *Geological Society of America, Cordilleran/Rocky Mountain Sections Annual Meeting Abstracts with Programs*, Spokane, Washington, May 1989, page 82.

Schiarizza, P., Garver, J.I., Glover, J.K., Gaba, R.G. and Umhoefer, P.J. (1990): Mid-Cretaceous Structural History of the Taseko Lakes - Bridge River Area, Southwestern British Columbia: Part of the Boundary between the Intermontane and Insular Superterranes; *Geological Association of Canada/Mineralogical Association of Canada, Annual Meeting*, Vancouver, British Columbia, Program with Abstracts, Volume 15, page A118.

Talks

Glover, J.K. (1988): "Tectonic Setting of Mineral Occurrences and Alteration Zones in the Warner Pass and Noaxe Creek Map Areas"; 1988 Cordilleran Roundup, in Vancouver, British Columbia, February 3, 1988.

Glover, J.K., Schiarizza, P., Garver, J.I. and Umhoefer, P.J. (1988): "Late Mesozoic to Cenozoic Tectonics, Taseko Lakes Area, Southwest British Columbia: Implications for Collision and Subsequent History of the Amalgamated Superterranes"; 2nd Southern

Cordilleran Geology Workshop, Pacific Geoscience Centre, Sidney, British Columbia, April 28, 1988.

Gaba, R.G. (1989): "Geology and Metallogeny of the Taseko - Bridge River Area"; 2nd Annual Kamloops Exploration Conference, Kamloops, British Columbia, April 7, 1989.

Schiarizza, P. and Gaba, R.G. (1990): "Structure, Plutonism and Metallogeny of the Taseko Lakes - Bridge River Area: A focus on new Exploration Targets"; 1990 Cordilleran Roundup, Vancouver, British Columbia, February 7, 1990.

Project name	WHITESAIL
MDA Expenditures	$478,244 (1987 - 1990)
	40,000 (Budgeted, 1991)
Principal researcher(s)	L. DIAKOW
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	WEST CENTRAL B.C.

OBJECTIVES To stimulate and guide industry exploration in the Whitesail area of west central British Columbia and improve the geological database in areas underlain by Mesozoic and Cenozoic volcano-plutonic arc assemblages perceived to have epithermal precious metal potential. This objective was to be achieved through 1:50 000 scale geological mapping and sampling for geochronologic, geochemical and petrographic studies. This project intended to lead to a better understanding of the temporal relationships of major igneous events and their evolution in the Stikine Terrane. Mineral deposits were to be classified and their salient features documented in order to delineate metallotects and aid exploration by private sector companies.

ACHIEVEMENTS Four 1:50 000 scale geological maps were produced which refined lithostratigraphic subdivisions of lower and middle Jurassic and Eocene volcanic rocks. New potassium and argon ages from volcanic and plutonic rocks helped to constrain timing of major magmatic events in the project area.

Porphyry copper and molybdenum mineralization in the Whitesail Lake area were found to be related to the emplacement of Late Cretaceous and Eocene granitoid intrusions. As well, high-level, base metal-rich quartz veins, some with sporadic gold-silver concentrations, were discovered to be generally controlled by steeply dipping extensional fractures and faults near the margin of many of these plutons.

IMPACT Mining company involvement in the area was consistently moderate throughout the duration of the Whitesail project. In 1988, publication of results for the Geochemical Reconnaissance Survey conducted in the Whitesail Lake area resulted in elevated staking activity and follow-up property evaluation. Regional mapping in conjunction with the RGS survey impacted on private sector programs by delineating favorable structure-alteration localities and new geochemically anomalous areas. These surveys also confirmed the close spatial and probable genetic relationship of Cretaceous and Eocene plutonism with precious metal bearing veins and porphyry type mineralization. Several companies have initiated programs to evaluate the precious metal potential of granitoid intrusions and associated high-level argillic alteration that had previously been explored for porphyry type mineralization.

MDA projects re-evaluated old deposits to develop models.

OUTPUTS

Fieldwork Articles

Diakow, L. and Mihalynuk, M. (1986): Geology of Whitesail Reach and Troitsa Lake Map Areas (93E/10W, 11E); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 171-179.

Diakow, L.J. and Koyanagi, V. (1987): Stratigraphy and Mineral Occurrences of Chikamin Mountain and Whitesail Reach Map Areas (93E/06, 10), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, pages 155-168.

Diakow, L.J. and Drobe, J. (1988): Geology and Mineral Occurrences in North Newcombe Lake Map Sheet (93E/14), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 183-188.

Diakow L.J. (1989): Geology of Nanika Lake Map Area (93E/13), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1990-1, pages 83-89.

Open Files

Diakow, L.J. and Mihalynuk, M. (1987): Geology of Whitesail Reach and Troitsa Lake Areas (93E/10W and 93E/11E); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1987-4.

Diakow, L.J. and Koyanagi, V. (1988): Geology of the East Half Whitesail Reach and Northeast Half Chikamin Mountain Map Sheets (93E/10, 93E/6), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1988-2.

Diakow, L. and Drobe, J. (1989): Geology and Mineral Occurrences in North Newcombe Lake Map Sheet (93E/14), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1989-1.

Papers

Hall, R. Poulton, T.P. and Diakow, L.J. (in press): Early Bajocian (Middle Jurassic) Ammonites and Bivalves from the Whitesail Lake Area, West-Central British Columbia, in Contributions to Canadian Paleontology, *Geological Survey of Canada*.

Talks

Presentations were made at the following:

- 1988 Cordilleran Roundup in Vancouver, British Columbia.
- An informal meeting of exploration geologists in Smithers, British Columbia in 1988.

Project name	MIDWAY-CASSIAR
MDA expenditures	$586,492 (1987-1990) 3,500 (Budgeted, 1991)
Principal researcher(s)	J. NELSON
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	NORTH CENTRAL B.C.

OBJECTIVES To help to focus private sector mineral exploration activity in the Midway-Cassiar area of northern British Columbia by determining the settings and controls of known gold-silver-lead-zinc deposits and evaluating the asbestos potential. The project intended to identify settings likely to host Midway type deposits and investigate other potential resources in order to contribute to geological knowledge of the area.

ACHIEVEMENTS Four contiguous 1:50 000 map sheets were produced in an area which previously had been mapped only at 1:250 000 scale. The much greater definition of large-scale mapping allowed subdivision and interpretation of the Sylvester allochthon, a complexly deformed Paleozoic oceanic package. The Sylvester allochthon was found to host two out of the three major mineral deposit types in the region: gold-quartz veins and asbestos. Both deposit types were determined to be partially controlled by the low-angle thrust faults that dominate the Sylvester structure. The outcrop extent of the McDame Group and the Devonian carbonates that host the Midway silver-lead-zinc manto deposit were also outlined.

IMPACT This mapping has aided both exploration companies and prospectors by delineating structures and lithologies of economic importance at appropriate levels of detail. Several mineral prospects discovered in the course of this project have either been staked or are under investigation by private sector parties. In particular, these include two silver-lead-zinc prospects, one rhodonite body that may be commercially exploitable, and an alteration zone linked to the Erickson gold-quartz system.

OUTPUTS

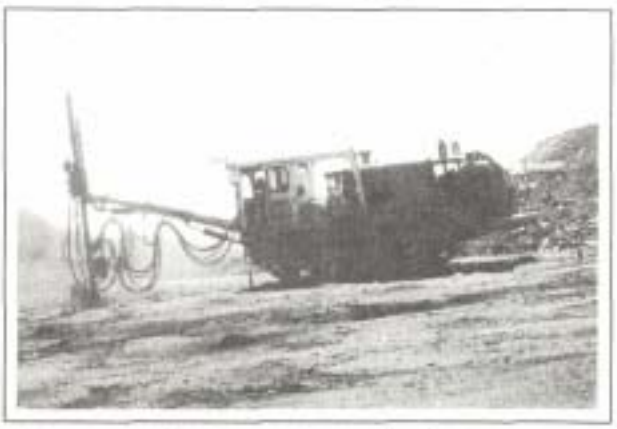
Fieldwork Articles

Nelson, J. and Bradford J. (1986): Geology of the Area Around the Midway Deposit Northern British Columbia (104O/16); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 181-192.

Nelson, J., Bradford, J.A., Green, K.C. and Marsden, H. (1987): Geology and Patterns of Mineralization, Blue Dome Map Area, Cassiar District (104P/12), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, pages 233-244.

Harms, T.A., Nelson, J. and Bradford, J. (1987): Geological Transect Across the Sylvester Allochthon North of the Blue River, Northern British Columbia (104P/12), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, pages 245-248.

Nelson, J.L. and Bradford, J.A. (1988): Geology and Mineral Deposits of the Cassiar and McDame Map Areas, British Columbia (104P/3, 5), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 323-338.



Industry has seized new opportunities thanks to over 60 MDA geological survey projects.

Harms, T.A. (1988): Geology of the Northeast Needlepoint Mountain and Erickson Mine Areas, Northern British Columbia (104P/4), Amherst College and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Field work 1988, Paper 1989-1, pages 339-346.

Nelson, J. (1989): The Blue Dome Fault: The Evolution of a Transform Structure into a Thrust Fault in the Sylvester Allochthon, Cassiar Mountains, British Columbia; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Field work 1989, Paper 1990-1, pages 217-222.

O'Hanley, D.S. (1989): The Structural Geology of the Mount McDame Area, North-Central British Columbia (104/P); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Field work 1989, Paper 1990-1, pages 223-228.

Nelson, J. (1989): Evidence for a Cryptic Intrusion Beneath the Erickson-Taurus Gold-Quartz Vein System, near Cassiar, British Columbia (104P/4 & 5); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Field work 1989, Paper 1990-1, pages 229-236.

Nelson, J., Hora, Z.D., and Harvey-Kelly, F. (1989): A New Rhodonite Occurrence in the Cassiar Area, Northern British Columbia; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Field work 1989, Paper 1990-1, pages 347-352.

Open Files

Nelson, J. and Bradford, J. (1987): Geology of the Midway Area (104O/16), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1987-5.

Nelson, J., Harms, T., Bradford, J., Green, K., and Marsden, H. (1988): Geology and Metallogeny, Blue Dome Map Area (104P/12), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1988-10.

Nelson, J. and Bradford, J. (1989): Geology and Metallogeny of the Cassiar and McDame Map Areas (104P/5;104P/3), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1989-9.

Harms, T. and Nelson, J. (1989): Geology of the Needlepoint Mountain Map Area (104P/4 Northeast Quarter), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1989-19.

Abstracts

Nelson, J. and MacIntyre, D. (1987): The Metallogeny of Northeastern British Columbia: a Tectonic Framework; *Geological Association of Canada Program with Abstracts*, Volume 12, page 76.

Nelson, J.L., Ferri, F., and Schiarizza, P. (1988): Emplacement of the Slide Mountain Terrane: Obduction or Shortening; *American Geophysical Union, Pacific Northwest Region, Proceedings of the 35th Annual Meeting*, page 6.

Nelson, J.L., Bradford, J.A., Ferri, P., and Schiarizza, P. (1989): Marginal Basin and Island Arc Elements in the Slide Mountain Terrane: Evidence for Early North American Affinities; *Geological Society of America Abstracts with Programs*, Volume 21, Number 5, page 121.

Talks

Presentations were made at the following:

- University of British Columbia, "Geology and Mineral Deposits of the Midway Area, Northern British Columbia"; in Vancouver, British Columbia, February 1987.
- Cordilleran Roundup, "Structure of the Sylvester Allochthon," in Vancouver, British Columbia, February 1988.
- Smithers Exploration Group Workshop, "Late Paleozoic Marginal Basin and Island Arc Environments in the Sylvester Allochthon and the Structural Framework of Mineralization in the Cassiar Camp", Smithers, British Columbia, October 1988.
- Cordilleran Tectonics Workshop, "North American Marginal Basins and Island Arcs in the Northern Slide Mountain Terrane," Vancouver, British Columbia, February 1989.
- Geological Association of Canada, Cordilleran Mineral Deposits Workshop, "Carbonate-Hosted Massive Sulfide Deposits," Vancouver, British Columbia, May 1990.

Project name	BULLMOOSE
MDA expenditures	$56,709 (1987)
Principal researcher(s)	W. KILBY
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	NORTHEAST B.C.

OBJECTIVES To assist with coal exploration in the northeastern part of British Columbia by mapping and describing the coal-bearing strata using automated computer-based techniques for data compilation, presentation and analysis.

ACHIEVEMENTS Two 1:50 000 scale geological maps were produced and data from the areas were compiled. In addition, two open file maps, orientation and formational data from 7600 outcrop stations were compiled and stored in a database.

IMPACT The mapping assisted one of the major land holders to reassess its exploration program and provide for a more efficient use of funds. Major interest in the mapping has come from the petroleum industry in their search for gas.

OUTPUTS

Fieldwork Articles

Kilby, W.E. and Wrightson, C.B. (1986): Bullmoose Mapping and Compilation Project (93P/3, 4); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, paper 1987-1, pages 373-378.

Open Files

Kilby, W. and Wrightson, C.B. (1987): Bedrock Geology of the Bullmoose Creek Area (93P/3), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1987-6.

Kilby, W. and Wrightson, C.B. (1987): Bedrock Geology of the Sukunka River Area (93P/4), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1987-7.

Project name	TECHNICAL EDITOR AND PUBLICATIONS INPUT
MDA expenditures	$160,818 (1987-1990) 30,000 (Budgeted, 1991)
Principal researcher(s)	J. NEWELL
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	VICTORIA

OBJECTIVES To optimize the impact of the MDA program by ensuring that program results met high editorial standards.

ACHIEVEMENTS All MDA open file maps, reports and manuscripts were edited. This helped to ensure the timely preparation of consistent, high quality products.

IMPACT As a result of this project, geological data generated from MDA activities were made available to the mineral exploration industry in a reliable and timely manner.

1.1.3 Metallogenic Mapping

Metallogenic Mapping - detailed studies of local geological environments to determine the specific geologic features that influence the location, size and grade of ore deposits so that theoretical models for mineralization processes can be developed to guide exploration.

Coal

Project name	FLATHEAD RIDGE
MDA expenditures	$1,381 (1986)
Principal researcher(s)	D. GRIEVE AND W. KILBY
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	SOUTHEAST B.C.

OBJECTIVES To guide industry exploration by providing a better understanding of the coal potential of the Flathead Ridge in the Crowsnest Coalfield of southeastern British Columbia. This objective was to be achieved by constructing a computer model to calculate coal resource figures for the Flathead Ridge area. This project intended to supplement a larger project investigating the entire Dominion Coal Block.

ACHIEVEMENTS All available data on the geology, coal quality and mining characteristics of the Flathead Ridge area were summarized and used to construct a computer model. Calculations based on this model verified the existence of significant quantities of coal, capable of being mined by underground methods. The summarized data and the model have been incorporated with the larger project.

IMPACT This study has heightened awareness of the Dominion Coal Block as a potential resource of metallurgical and thermal coal and coalbed methane. Measurable impacts are not yet available, as the land tenure situation does not encourage development (coal rights are held by the federal government).

OUTPUTS

Fieldwork Articles

Grieve, D.A. and Kilby, W.E. (1985): Flathead Ridge Coal Area, Southern Dominion Coal Block (Parcel 82); Southern British Columbia (82G/7), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1985, Paper 1986-1, pages 25-36.

Papers

Grieve, D.A. and Kilby, W.E. (1989): Geology and Coal Resources of the Dominion Coal Block, Southeastern British Columbia, *British Columbia Ministry of Energy Mines and Petroleum Resources*, Paper 1989-4.

Talks

Grieve, D.A. and Kilby, W.E. (1986): "Computer Modelling of Coal Resources in the Dominion Coal Block," Southeastern British Columbia. A presentation to the Canadian Institute of Mining and Metallurgy District 6 Meeting, Victoria, British Columbia, October 1986.

Project name	COAL PETROLOGY
MDA expenditures	$4,000 (1986)
Principal researcher(s)	J. SCHWEMLER
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	VICTORIA

OBJECTIVES To determine the thermal maturity of sedimentary rocks by undertaking vitrenite reflectance analysis. This project intended to provide technical support to the Elk Valley project.

ACHIEVEMENTS Analyses were completed and used in a study of the coal measures around Weary Ridge and Bleasdell Creek in the Elk Valley.

IMPACT The rank of the coal in the Elk Valley is critical to the understanding of the coal quality. The ultimate end use of the coal and its coalbed methane potential are both characterized by the reflectance values.

OUTPUTS

Fieldwork Articles

Grieve, D.A. (1986): Subsurface Coal Rank Profiles, Ewin Pass to Bare Mountain, Elk Valley Coalfield, Southeastern British Columbia (82G/15, 82J/2); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 351-360.

Grieve, D.A. (1986): Coal Rank Distribution, Flathead Coalfield, Southeastern British Columbia (82G/2, 82G/7); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 361-364.

Project name	ELK VALLEY
MDA expenditures	$19,514 (1986 - 1987)
Principal researcher(s)	D. GRIEVE
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	SOUTHEAST B.C.

OBJECTIVES To acquire and publish basic information concerning the north half of the Elk Valley Coalfield, the least understood portion of the southeastern British Columbia coalfields. This project intended to develop a model of the geology of Weary Ridge in the Elk River and Fording River properties in order to determine its potential for open-pit mining, as a possible alternative to the proposed Elco Mining mine-site on Little Weary Ridge. A comprehensive Bulletin was to be compiled which would guide future development of the entire Elk Valley Coalfield.

ACHIEVEMENTS Geological mapping of the area was completed at 1:10 000 scale on an orthophoto base. For large portions of the study area, this is the only geological map currently available. Modelling of the stratigraphic sequences in sections and cores has yielded new insight into the deposition of fluvial-alluvial sediments in the Kootenay Group. Exposed coals were sampled and ranked and maceral compositions were determined. The distribution of coal ranks, which is somewhat anomalous in the study area, is now much better understood. A comprehensive Bulletin is currently being prepared.

IMPACT This study has generated interest within Fording Coal Limited. The published maps will be of benefit to licence holders in the area, and to those evaluating the relative potential of the coal reserve at the north end of the Elk Valley. The Bulletin will be a widely used reference for all geologists working with the Kootenay Group coals in southeastern British Columbia and will guide both private and public sector decisions regarding future development in the region.

OUTPUTS

Fieldwork Articles

Grieve, D.A. (1986): Weary Ridge and Bleasdell Creek Areas, Elk Valley Coalfield (82J/7); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 345-350.

Five coal studies examined new prospects for metallurgical and thermal coal and coalbed methane resources in B.C.

Morris, R.J. and Grieve, D.A. (1988): Elk Valley Coalfield, North Half; (82J/02,07,10,&11) *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1987, Paper 1988-1, pages 427-434.

Other Publications

Grieve, D.A. (1989): Stratigraphy of the Mist Mountain Formation (Jurassic-Cretaceous Kootenay Group) in the Elk Valley Coalfield, Southeastern British Columbia, in Advances in Western Canadian Coal Geoscience - Forum Proceedings, *Alberta Research Council*, Information Series, Number 103, pages 24-41.

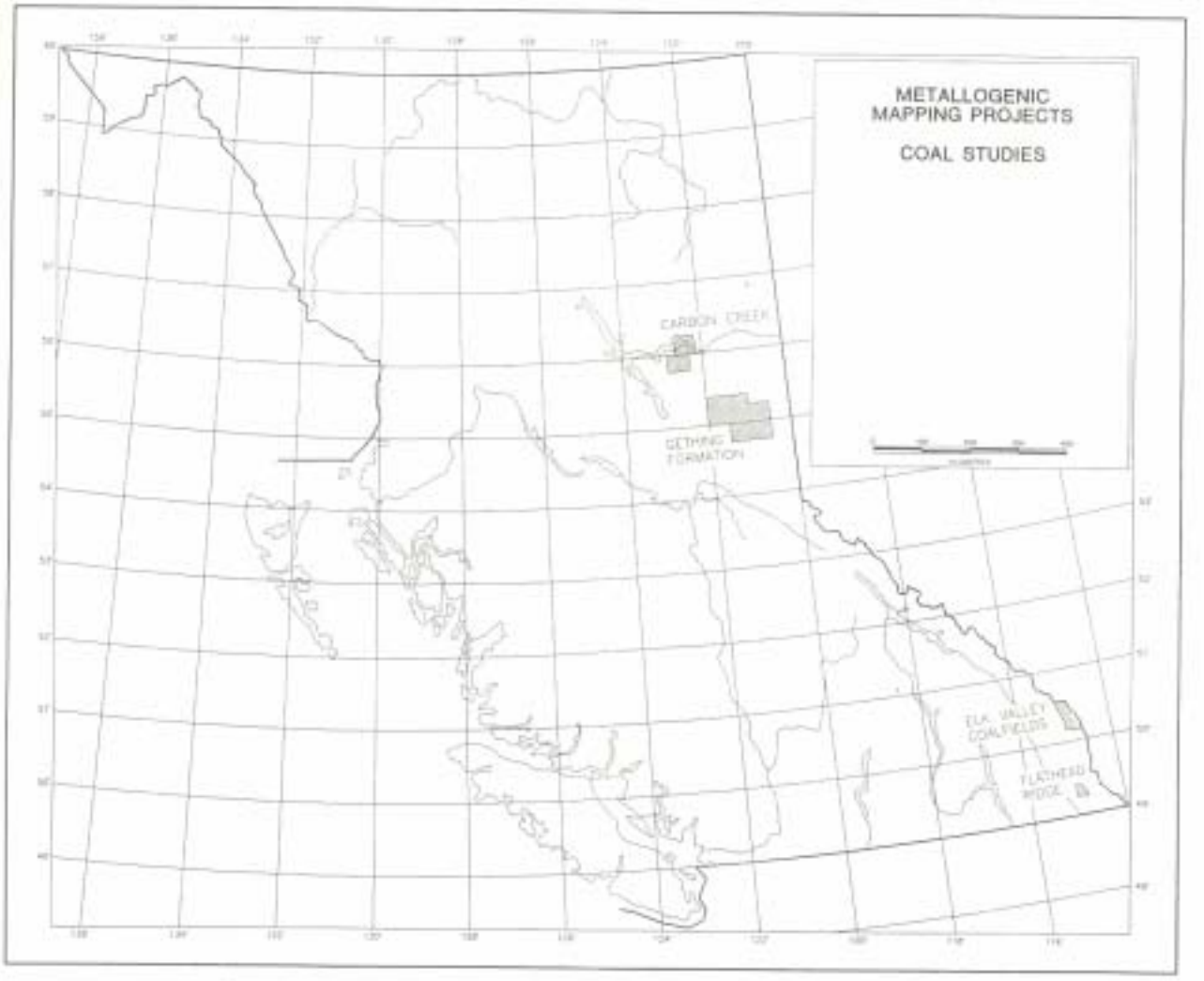
Morris, R.J. & Grieve, D.A. (1990): Geology of the Elk Valley Coalfield, North Half, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Preliminary Map 68.

Grieve, D.A. (in preparation): Geology and Resources of the Elk Valley Coalfield, Southeastern British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Bulletin.

Project name	COAL TRENDS IN THE GETHING FORMATION
MDA expenditures	$21,204 (1987-1988)
Principal researcher(s)	A. LEGUN
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	NORTHEAST B.C.

OBJECTIVES To assist industry by conducting an analysis of coal thickness trends in the Gething Formation of northeastern British Columbia, near the Bullmoose and Quintette mine areas.

ACHIEVEMENTS This project produced a stratigraphic fence diagram of the Gething Formation in the southern half of the Peace River coal belt. Reference sections for the Gething Formation are now available for large areas that include the coal belt and the plains. The Gething Formation was subdivided into three members and a database



integrating data from coal boreholes, petroleum wells, trenching and measured sections was compiled. A 1:100 000 scale geological map was produced.

IMPACT The project is awaiting publication. Its impact is expected to be improved stratigraphic control for coal, petroleum exploration and other studies involving correlations. Units in the coal belt may have significance in the plains (e.g., gas bearing porous sandstones) and units in the plains (coal intersections) may have significance in the coal belt. The stratigraphic database will be useful in a regional assessment for coalbed methane. The study reconciles the stratigraphic framework of two geologic disciplines (coal and petroleum).

OUTPUTS

Fieldwork Articles

Legun, A. (1987): Coal Trends in the Gething Formation - An Update; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, pages 459-462.

Papers

Legun, A. (in preparation): Stratigraphic Trends in the Gething Formation, Sukunka-Kinuseo Creek Area, Peace River District (NTS 93P/1 t 93P/8, 93I/14 and 15).

Talks

Legun, A. (1986): "Coal Thickness Trends and Lithofacies of the Upper Gething Formation (Chamberlain Member), Northeastern British Columbia," Western Canada Coal Geoscience Forum, November 17 - 19, 1986, Calgary, Alberta.

Project name	CARBON CREEK
MDA expenditures	$3,045 (1987)
Principal researcher(s)	A. LEGUN
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	NORTHEAST B.C.

OBJECTIVES To compile updated information on coal formations in the Carbon Creek area of northeastern British Columbia in order to assist industry in exploration and add to the geological database on the area.

ACHIEVEMENTS A 1:50 000 scale geological map was produced which traced the major coal seams in the Carbon Creek basin and more clearly defined the areal extent of the coal measures. Stratigraphic thickness data were compiled, new sections measured, regional cross-sections produced and the sedimentology of Jurassic-Cretaceous Formations described.

IMPACT A number of oil exploration companies and consulting firms have made enquires about the project. The structural and stratigraphic definition of the mapped area is of a quality that enables the interpretation of subsurface petroleum plays. Stratigraphic thickness data has proved useful for calculating depth of reservoir rocks (Triassic and older) beneath mapped structures. The impact on coal exploration to date, however, has been minimal, likely due to the fact that other areas in the Peace River coalbelt have shown greater potential.

OUTPUTS

Fieldwork Articles

Legun, A. (1986): A Geological Update of the Carbon Creek and Butler Ridge Areas (930/15 & 94B/1); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 365-367.

Papers

Legun, A. (1988): Geology and Coal Resources of the Carbon Creek Map Area; *British Columbia Ministry of Energy, Mines and Petroleum Resources*; Paper 1988-3.

Other Publications

Legun, A. (1986): The Geology of the Carbon Creek Area (93O/15), Geological Survey of Canada, Program and Abstracts, Western Canada Coal Geoscience Forum, November 17 - 19, 1986, Calgary, Alberta.

Gold

Project name	HEDLEY GOLD
MDA expenditures	$89,398 (1987)
Principal researcher(s)	G. RAY AND G. DAWSON
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	SOUTH CENTRAL B.C.

OBJECTIVES To guide precious metal exploration by mapping the Hedley gold skarn camp in the southern Okanagan region and determining the controls on mineralization. This project intended to outline deposit models which would guide and assist exploration programs for skarns in other parts of the province.

ACHIEVEMENTS Geochemical sampling was undertaken at the Nickel Plate, French, Canty and Goodhope mines. Core logging studies of the Nickel Plate deposit and geochemical microprobe studies of the garnet-pyroxene assemblages associated with the various skarn deposits were completed. U-Pb zircon analysis was used for age dating. The ages of the sedimentary rocks in the district were determined using conodont microfossils. A deposit model for gold skarns was established, which should prove useful for gold skarn exploration elsewhere in the province.

The Nickle Plate mine near Hedley, B.C. is the site of the largest gold skarn in Canada.

IMPACT This project has helped make the exploration community aware of the potential of gold skarns. Battle Mountain Gold Limited is currently exploring gold skarns in the Greenwood area, and Noranda Minerals Incorporated is looking at the Merry Widow skarn on Vancouver Island. The mapping outlined a potential skarn area south of the Nickel Plate deposit which has been staked and is currently being explored by Chevron Minerals Limited. A massive garnet deposit was also outlined on Mount Riordan (Crystal Peak) which Polestar Explorations Incorporated has since proposed for development. This project is currently before the provincial Mine Development Review Process.

OUTPUTS

Fieldwork Articles

Ray, G.E. and Dawson, G.L. (1986): The Geology and Controls of Skarns Mineralization in the Hedley Gold Camp, Southern British Columbia (92H/8 & 82E/5); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 65-80.

Ray, G.E., Dawson, G.L., and Simpson, R. (1987): Geology, Geochemistry and Metallogenic Zoning in the Hedley Gold-Skarn Camp (92H/08 & 82E/05); Mascot Gold Mines Limited and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, pages 59-80.

Open Files

Ray, G.E. and Dawson, G.L. (1987): Geology and Mineral Occurrences in the Hedley Gold Camp, Southern British Columbia (92H/8), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1987-10.

Other Publications

Ray, G.D. and Dawson, G.L. (in preparation): The Geology and Mineral Deposits of the Hedley Gold Skarn District, Southern British Columbia; *British Columbia Ministry of Energy Mines and Petroleum Resources*, Bulletin 83.

Talks

Presentations were made at the following:

- Prospectors and Developers Association of Canada Annual Meeting in Toronto, Ontario, 1987.
- Annual Meeting of the Canadian Institute of Mining and Metallurgy in Vancouver, British Columbia, 1987.
- Kamloops Mining Conference, Kamloops, British Columbia, 1989.

Project name	GOLD SKARNS
MDA expenditures	**$61,499 (1988)**
Principal researcher(s)	G. RAY AND A. ETTLINGER
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	PROVINCE WIDE

OBJECTIVES To stimulate industry interest in the potential of gold-bearing skarns in British Columbia by compiling data on all known gold and silver bearing skarns, including details on geology, geochemistry, mineralogy and mining production. The controls on gold skarn mineralization in the province, with regards to distribution, tectonic terrain and age of host rock, were to be determined.

ACHIEVEMENTS Detailed mapping at 1:20 000 scale and sampling was completed at 10 gold skarn mining camps in British Columbia, including Hedley, Texada Island, Zeballos, Merry Widow, Tillicum Mountain, Greenwood and Banks Island. Data were compiled and published on 126 precious metal enriched scarns occurrences.

IMPACT This project has contributed to an understanding of gold skarns in the province and generated exploration interest. Battle Mountain Gold Company has undertaken exploration work at Greenwood in the southern interior of the province and at Zeballos on northern Vancouver Island, and Noranda Minerals Limited has explored the skarns at Merry Widow on northern Vancouver Island. Industry exploration activity on Texada Island and in the Iskut River area of northwestern British Columbia has also been stimulated.

The Ministry of Energy, Mines and Petroleum Resources has received numerous national and international inquiries about the gold skarn potential of the province as a result of this investigation. As well, this project led the way for a large program, currently underway, which is looking at all of the province's skarn deposits (iron, copper, gold, tungsten, tin, molybdenum and lead-zinc).

OUTPUTS

Fieldwork Articles

Ettlinger, A.D. and Ray, G.E. (1987): Gold-Enriched Skarn Deposits of British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, pages 263-279.

Papers

Ettlinger, A.D. and Ray, G.E. (1989): Precious Metal Enriched Skarns in British Columbia: An Overview and Geological Study, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Paper 1989-3.

Ray, G.E. (1990): "West Coast Skarns." *The Northern Miner Magazine*, April 1990, pages 22-27.

Talks

Presentations were made at the following:

- Prospectors and Developers Association of Canada Annual Meeting in Toronto, Ontario, 1988.
- Canadian Institute of Mining and Metallurgy Meeting in Vancouver, British Columbia, 1988.
- 2nd Annual Kamloops Exploration Conference in Kamloops, British Columbia, 1989.
- Society of Economic Geologists Meeting, Utah, 1990.
- Joint Meeting of Geological Association of Canada and the Mineralogical Association of Canada in Vancouver, British Columbia, 1990.
- Saskatchewan Geology and Mining Association Meeting in Regina, Saskatchewan, October 1990.

Project name	NORTHWESTERN BRITISH COLUMBIA GOLD STUDIES
MDA expenditures	$13,485 (1986)
Principal researcher(s)	TOM SCHROETER
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	NORTHWEST B.C.

OBJECTIVES To stimulate and enhance mineral exploration activity in northwestern British Columbia by examining precious metal deposits in the Muddy Lake (e.g. Golden Bear), Toodoggone River and Bennett Lake areas, and precious-base metal massive sulphide deposits in the Tatshenshini area (e.g. Windy Craggy, Mount Henry Clay). This was to be achieved through sampling and mapping of selected deposits.

ACHIEVEMENTS The study and examination of selected mineral prospects, on both property and regional scales, served to document and update information for MINFILE. In particular, the Toodoggone, Muddy Lake, Bennett Lake and Tatshenshini areas were examined and documented, with a specific emphasis on deposit types.

IMPACT By using the Toodoggone area as an example, a British Columbia Epithermal Model was developed and is being used by the private sector. Mineral exploration continued at an advanced stage on several properties studied during the project, the most significant culminating with the opening of the Lawyers gold-silver mine in January 1989. The Omineca Resource Road was completed into the area in 1989 to serve the Lawyers mine and benefit further exploration.

In the Muddy Lake area, documentation of 'no-see-um' type gold mineralization in a new area stimulated regional exploration. In 1989, road access was established to the Golden Bear mine which officially opened in early 1990. Several promising properties on a regional scale remain to be thoroughly tested.

The Bennett Lake mini-project drew attention to the area as a potential host for primarily precious metals bearing vein-type deposits. Since the study, several mining companies have acquired ground in the area and have conducted advanced exploration programs, especially along the Llewellyn fault system. The Geological Survey Branch initiated a systematic program of 1:50 000 scale geological mapping in 1987 which is still in progress.

In the Tatshenshini area, attention focussed on the similarities/differences between the world class Windy Craggy massive sulphide deposit and deposits in the Mount Henry Clay area. Continued work on the Windy Craggy deposit has brought the project to the feasibility stage, including submission to the Mine Development Review Committee.

OUTPUTS

Fieldwork Articles

Schroeter, T.G., Diakow, L.J., and Panteleyev, A. (1985): Toodoggone River Area (94E), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1985, Paper 1986-1, pages 167-174.

Schroeter, T.G. and MacIntyre, D.G. (1985): Tatshenshini Map-Area (114P), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1985, Paper 1986-1, pages 191-196.

Schroeter, T.G. (1985): Muddy Lake Project (104K/1), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1985, Paper 1986-1, pages 175-185.

Schroeter, T.G.(1985): Bennett Project (104M), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1985, Paper 1986-1, pages 185-189.

Schroeter, T.G. (1986): Golden Bear Project (104K/1); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 103-110.

Talks

A presentation was made at a Gold Conference in Reno, Nevada, U.S.A. in October, 1988.

Project name	SOUTHERN BRITISH COLUMBIA GOLD STUDIES
MDA expenditure	$29,797 (1987)
Principal researcher(s)	T. SCHROETER
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	SOUTHERN B.C.

OBJECTIVES To encourage precious metal exploration in southern British Columbia by studying gold-bearing mineral deposits in the Abo, Blackdome, Bralorne-Bridge River, Grand Forks-Greenwood, Hedley, Tillicum and Willa areas.

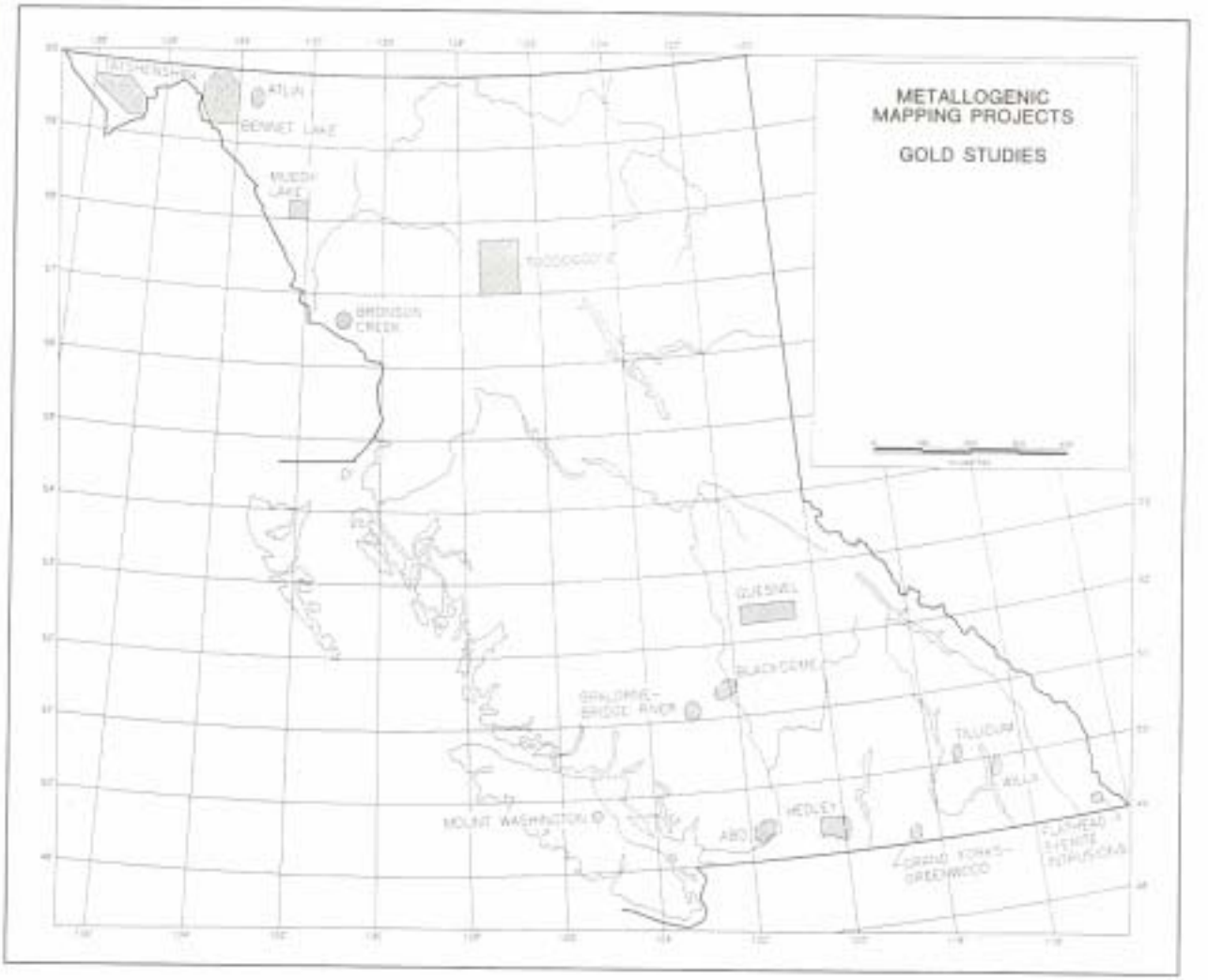
ACHIEVEMENTS A variety of gold depostis were visited and a written summary of "type" deposits was produced which included such topics as: regional and local geology, composition of host rocks, age of host rocks, structural controls, mineralogy of ore, and gangue, alteration assemblages, fluid inclusion and isotope data (if available), age of alteration and/or mineralization, classification of deposit and deposit correlations/comparisons including modelling and metallogenesis.

IMPACT This project has provided up to date information on gold deposits in southern British Columbia. The data collected has already been of use to companies currently exploring in the area.

OUTPUTS

Fieldwork Articles

Schroeter, T. (1986): Brief Studies of Selected Gold Deposits in Southern British Columbia; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 15-22.



Talks

Presentations were made at the following:

- Gold Conference in Reno, Nevada, U.S.A. in October 1988.
- Annual Cordilleran Round-up in Vancouver, British Columbia, 1988.

Project name	NORTHWESTERN BRITISH COLUMBIA STUDIES
MDA expenditures	$12,207 (1987)
Principal researcher(s)	D. LEFEBURE
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	NORTHWEST B.C.

OBJECTIVES To promote exploration in northwestern British Columbia by identifying geologically favourable areas for precious metals exploration.

ACHIEVEMENTS Detailed geological maps with up-to-date compilations of industry data were prepared for the Bronson Creek and Atlin areas. The settings of the major mineral occurrences were determined and little known prospects were identified. This project produced the first published geological map at any scale for the Bronson Creek area. In the Atlin area, the work led directly to a Geological Survey Branch A-Base program of 1:50 000 scale mapping.

IMPACT Bronson Creek and Atlin were two of the more active exploration areas of British Columbia from 1987 to 1989. Both areas were almost completely covered by claims with numerous companies drilling on their properties. The Northwest British Columbia MDA project provided exploration geologists with access to regional expertise both in the field and through publications. The field work in the Bronson Creek area led directly to a regional Jurassic model for gold-silver-copper mineralization modified from earlier work completed near Stewart.

OUTPUTS

Fieldwork Articles

Bloodgood, M.A., Rees, C.J. and Lefebure, D.V. (1988): Geology and Mineralization of the Atlin Area, Northwestern British Columbia (104N/11W and 12E), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 311-322.

Open Files

Lefebure, D.V. and Gunning, M.H. (1989): Geological Compilation Map of the Atlin Area, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1989-24.

Lefebure, D.V. and Gunning, M.H. (1989): Geology, Lithogeochemistry and Mineral Occurrences of the Bronson Creek Area, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1989-28.

Papers

Lefebure, D.V. (1986): Red River (Sulphurets), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Exploration in British Columbia, 1986, pages B57-B62.

Lefebure, D.V. and Gunning, M.H. (1987): Gold Lithogeochemistry of Bronson Creek Area, British Columbia (104B/10W and 11E), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Exploration in British Columbia 1987, pages B71-B77.

Lefebure, D.V. and Gunning, M.H. (1987): Yellowjacket, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Exploration in British Columbia 1987, pages B87-B95.

Talks

Lefebure, D.V., Bloodgood, M.A. and Rees, C. (1988): "Lode Gold Deposits of the Atlin Area," Geology and Metallogeny of Northwestern British Columbia Workshop, Smithers, British Columbia.

Lefebure, D.V. (1988): "Geology of the Bronson Creek Area," Bronson Creek Field Conference, Bronson Creek, British Columbia.

Lefebure, D.V. (1989): "Gold Deposits of the Stewart-Iskut River Gold Belt, British Columbia", Prospectors and Developers Association Annual Meeting, Toronto, Ontario.

MDA projects have helped the B.C. mining industry target most likely areas for mineral exploration.

Project name	QUESNEL GOLD
MDA expenditures	$94,377 (1987)
Principal researcher(s)	A. PANTELEYEV
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	CENTRAL B.C.

OBJECTIVES To supply industry with new, uniformly consistent regional geological information on the base and precious metal deposits in the Quesnel mineral belt of central British Columbia. Through a program of 1:50 000 scale geological mapping, this project intended to conduct detailed structural studies of the gold deposits in the region.

ACHIEVEMENTS A 1:50 000 scale regional mapping program was initiated in 1986 using MDA funding for field activities and capital equipment costs. The project was extended for two additional years using Ministry funding. Approximately 300 square kilometers were mapped at 1:50 000 scale in 1986 and a number of radiometric, assay/geochemical and fossil samples were collected. In the central volcanic axis, evidence of widespread low temperature hydrothermal activity (including some mercury mineralization) was noted. In the basal black phyllite unit, the stratigraphy and structural complexity of the host rocks for gold-quartz vein mineralization was resolved.

IMPACT A geologically consistent mapping base was provided to the north of Quesnel River and south of Quesnel Lake. It extended and outlined lithologically favourable regions previously described. The mapping supported and emphasized the southward extension of highly mineralized environments, leading to a more effective assessment and reassessment of mineral claims in volcanic-intrusive regions.

Studies in the black phyllite unit did much to resolve the structural controls and origins of auriferous quartz veins in the Eureka Peak area. The findings contributed towards the understand-ing of similar mineralization in northern parts of this belt of rocks in the Spanish Mountain area and to the north of Quesnel River.

OUTPUTS

Fieldwork Articles

Panteleyev, A. (1986): Quesnel Gold Belt - Alkalic Volcanic Terrane Between Horsefly and Quesnel Lakes (93A/6); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 125-134.

Bloodgood, M.A. (1986): Geology of the Triassic Black Phyllite in the Eureka Peak Area, Central British Columbia (93A/7); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 135-142.

Panteleyev, A. (1987): Quesnel Mineral Belt - The Central Volcanic Axis Between Horsefly and Quesnel Lakes (93A/05E & 06W); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, pages 131-138.

Bloodgood, M.A. (1987): Geology of the Quesnel Terrane in the Spanish Lake Area, Central British Columbia (93A/11); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1988-1, pages 139-145.

Open Files

Bloodgood, M.A. (1987): Geology of Eureka Peak - McKay River (93A/7), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1987-9.

Marks, K.E., Bloodgood, M.A. and Panteleyev, A. (1987): Near Shore Mineral Resources, Deep Sea Ridge Systems and Metal Deposits, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1987-20.

Panteleyev, A. and Hancock, K. (1989): Geology of the Beaver Creek-Horsefly River Map Area (93A/5 & 6), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1989-14.

Bailey, D. (1989): Geology of the Swift River Area (93A/12; 93B/16 & 93G/1), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1989-20.

Bailey, D. (1990): Geology of the Central Quesnel Belt, British Columbia (NTS 93A, 93B, 93G 93H), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1990-31.

Papers

Bloodgood, M.A. (1990): Geology of the Eureka Peak - Spanish Lakes Area, British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Paper 1990-03.

Other Publications

Panteleyev, A., Bailey, D.G., Hancock, K. and Bloodgood, M.A. (1991): Geology and Mineral Deposits of the Quesnel and Horsefly River Map Area, Quesnel Terrain, Central British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Bulletin in preparation.

Talks

Panteleyev, A. (1987): "Quesnel Project Summary 1986." A presentation at the Cordilleran Roundup in 1987 in Vancouver, British Columbia.

Bloodgood, M.A. (1988): "Geology and structural development of the Triassic black phyllite unit in the Quesnel Terrain, Central British Columbia." A presentation to the Geological Society of America Meeting in 1988 in Hawaii, U.S.A.

Project name	VANCOUVER ISLAND, ISLAND METALLOGENY
MDA expenditures	$13,470 (1986-1987)
Principal researcher(s)	P. WILTON
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	VANCOUVER ISLAND

OBJECTIVES To re-examine the ore controls and age relationships of mineralization at a number of gold properties on Vancouver Island, with particular emphasis on suspected Tertiary-age mineralization at Mount Washington, Zeballos and Kennedy River, in order to guide exploration into new areas. This was to be achieved through 1:50 000 scale geological mapping.

ACHIEVEMENTS The major field component consisted of systematic mapping and detailed examination of mineralized showings at Mount Washington. This resulted in the better definition of a suspected late-Tertiary epithermal gold camp in which the major mineralization was related to shallow-dipping structures of unknown tectonic significance. A variety of other gold occurrences on Vancouver Island were visited and examined. Samples of alteration and intrusive rocks believed to be directly related to mineralization were collected for future examination and dating.

IMPACT As a result of this project, companies and prospectors became more aware of the potential for unrecognized Tertiary mineralization associated with flat structures on Vancouver Island. Two later research projects undertaken by the British Columbia Geological Survey Branch were initiated on the basis of observations made and conclusions reached in this study.

OUTPUTS

Papers

Wilton, H. P. (1986): Mount Washington (Domineer, Murex), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Exploration in British Columbia 1986, pages B29-B32.

Project name	MT. WASHINGTON MINERAL DEPOSIT
MDA expenditures	$10,000 (1989)
Principal researcher(s)	R. DAHL
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Other participating agencies	CARLTON UNIVERSITY
Project location	VANCOUVER ISLAND

OBJECTIVES To assist industry exploration by providing a detailed and comprehensive description of the mineral deposits presently being explored at Mount Washington on Vancouver Island. This project intended to clarify the age, origin and tectonic setting of the mineralization and compare it with similar occurrences at Gem Lake, Faith Lake, Piggot Creek and Wolf Creek.

ACHIEVEMENTS Approximately five weeks of detailed field mapping on Mount Washington were completed. A limited amount of petrographic and analytical work was carried out on samples collected.

IMPACT Some of the observations made in this study represent significant contributions to the understanding of Mount Washington geology and the origin of its mineral deposits. Results have been used and referenced in other research (most significantly in Geological Fieldwork, 1988).

OUTPUTS

Talks

Dahl, R., Watkinson, D.H., Wilton, H.P. and Bristow, J.H. (1989): "Geological and Tectonic Setting of the Mount Washington Gold Deposit, Vancouver Island, British Columbia, Canada," Gold 89 (an international symposium on gold metallogeny) in Toulouse, France, May 1989.

Project name	FLATHEAD SYENITE INTRUSIONS
MDA expenditures	$9,857 (1989)
Principal researcher(s)	A. LEGUN
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	SOUTHEAST B.C.

OBJECTIVES To guide private sector exploration in southeastern British Columbia by examining the potential size and distribution of gold occurrences in the Flathead syenite intrusions. This project intended to add to geological knowledge on the type, setting, structure, timing and relations of the syenites.

ACHIEVEMENTS Geological mapping at the 1:10 000 scale was undertaken in the Howell Creek area, focusing on the structural setting of alkalic intrusives. The project was able to redefine the trace of a number of important faults because a series of recent forest fires had increased exposure in the area. The intrusives were subdivided according to petrography and chemistry and the alterations were described.

IMPACT The project has generated enquires from a variety of exploration companies regarding the regional setting of the intrusives. Draft copies of the map have been distributed. Shell Canada Resources Limited is using the information to pursue the potential relationship between intrusives and high CO_2 generation in wells in the Flathead area. The project's dating of the age of the intrusives as Cretaceous rather than Tertiary, provided valuable information for an exploration play based on similarities to gold bearing Tertiary intrusives in the United States. The Geological Survey of Canada have also expressed an interest in the project.

OUTPUTS

Papers

Skupinski, A. and Legun, A. (1988): Geology of Alkalic Rocks at Twentynine Mile Creek, Flathead River Area, Southeastern British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Exploration in British Columbia 1988, pages B29-B34.

Other

Project name	ALICE ARM
MDA expenditures	$60,042 (1986)
Principal researcher(s)	D. ALLDRICK
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	NORTHWEST B.C.

OBJECTIVES To stimulate industry exploration by documenting the regional geological setting and delineating areas of high mineral potential in the Kitsault River valley in the Alice Arm area of northwestern British Columbia. This was to be achieved through 1:50 000 scale geological mapping.

ACHIEVEMENTS A 700 square kilometre area was mapped at 1:50 000 geological scale, and several mineral occurrences were examined. The project demonstrated that all silver-rich deposits in the region were hosted within a single stratigraphic unit.

IMPACT A new celestite-pyrite showing, the IAN prospect, was discovered by one of the mapping team. The data from this program has been used by both Dolly Varden Mines Limited and Cominco Limited to guide additional claim staking in the area. Follow-up prospecting on Cominco's new ground has discovered additional showings around Kitsault Lake.

OUTPUTS

Fieldwork Articles

Dawson, G. L. and Alldrick, D. J. (1985): Geology and Mineral Deposits of the Kitsault Valley (103P/11 & 12), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1985, Paper 1986-1, pages 219-224.

Alldrick, D.J. (1988): Volcanic Centres in the Stewart Complex (103P and 104A & B), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 233-240.

Open Files

Alldrick, D.J., Dawson, J.A., Bosher, J.A. and Webster I.C.L. (1986): Geology of the Kitsault River Area (103P) (1:50 000), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1986-2.

Other Publications

MINFILE 1030,P: 120 entries in the 1990 MINFILE release were coded as part of this project.

Project name	BARRIERE
MDA expenditures	$32,663 (1986)
Principal researcher(s)	P. SCHIARIZZA
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	SOUTHEAST B.C.

OBJECTIVES To guide industry exploration in southeastern British Columbia by extending southward an earlier mapping program carried out in the Adams Plateau - Clearwater area to include the Vavenby region. This project intended to provide a more complete understanding of the stratigraphy and structure of rocks assigned to the Eagle Bay Formation and evaluate its massive sulphide potential. The distribution and genesis of large-tonnage low-grade copper occurrences, such as the Harper Creek deposit, were also to be determined.

ACHIEVEMENTS The mapping program, which included the discovery of fossil *archaeocyathids*, established that rocks assigned to the Eagle Bay Formation included both a lower Paleozoic and a Devono-Mississippian succession. This led to the recognition of a major thrust-imbrication within the Eagle Bay assemblage. The project resulted in an improved understanding of Eagle Bay stratigraphy and the diverse tectonic environments, which in turn created a better understanding of the different types of mineral deposits hosted. Specifically: 1) sediment-hosted Ag-Pb-Zn massive sulphide deposits were found to occur within

a Lower Cambrian volcanic-sedimentary package that probably accumulated in a rift environment; 2) volcanogenic massive sulphides were discovered within a Devonian volcanic assemblage that probably represents arc-related volcanism; 3) disseminated copper mineralization was found to be spatially associated with Devonian granitoid intrusives that were probably comagmatic with the arc assemblage; and 4) uranium-flourine mineralization was determined to be syngenetic with trachytic volcanic and intrusive rocks that could be related to an extensional regime late in the history of the Devonian arc.

IMPACT This project was undertaken in an area that has been the focus of considerable exploration activity. The geological maps and reports produced have been widely used by explorationists because they delineate areas and rock units favorable for specific styles of mineralization within the diverse Eagle Bay package.

OUTPUTS

Fieldwork Articles

Schiarizza, P. (1985): Geology of the Eagle Bay Formation Between the Raft and Baldy Batholiths (82M/5, 11 & 12); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1985, Paper 1986-1, pages 89-94.

Open Files

Schiarizza, P. (1986): Geology of the Vavenby Area (82M/12 and parts of 5 and 11), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1986-5.

Papers

Schiarizza, P. and Preto, V.A. (1987): Geology of the Clearwater-Vavenby-Adams Plateau Area, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Paper 1987-2.

Talks

Schiarizza, P. (1988): "Regional Geology and Mineral Deposits of the Adams Plateau - Clearwater Region." A presentation given at the Kamloops Exploration Conference in Kamloops, British Columbia, 1988.

Project name	CHILKO LAKE
MDA expenditures	$103,005 (1986-1987)
Principal researcher(s)	G. MCLAREN
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	SOUTH CENTRAL B.C.

OBJECTIVES To document the mineral potential and stimulate further industry evaluation of an area that is a candidate for provincial park status in the Chilko Lake area of south central British Columbia. This was to be achieved through 1:50 000 scale geological mapping, detailed stream sediment geochemical surveying, prospecting and extensive lithogeochemical sampling.

ACHIEVEMENTS Mapping identified favourable geologic environments for at least four types of deposits (porphyry, vein, skarn and massive sulphide). Stream sediment geochemical anomalies further refined areas of higher mineral potential within favourable environments. Prospecting and lithogeochemistry resulted in discoveries of porphyry and vein-type mineralization and confirmed the tenor of known mineralization. Zones of high mineral potential can now be confidently identified.

IMPACT Mineral claim staking followed quickly after each year's release of information. Exploration work has been conducted on at least five separate claim groups as well as some limited follow-up to the stream sediment data on a regional basis. Industry interest in the area continues to be high. Between this study and the industry follow-up, a thorough evaluation of a future park status has been achieved.

OUTPUTS

Fieldwork Articles

McLaren, G.P. (1985): Geology and Mineral Potential of the Chilko-Taseko Lakes Area (92O/4, 5; 92J/13; 92K/16; 92N/1), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1985, Paper 1986-1, pages 265-274.

McLaren, G.P. (1986): Geology and Mineral Potential of the Chilko Lake Area (92N/1, 8; 92O/4); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 231-243.

Open Files

McLaren, G.P. (1986): Stream Sediment Geochemistry of the Chilko-Taseko Lakes Area, *British Columbia Ministry of Energy Mines and Petroleum Resources*, Open File 1986-6.

McLaren, G.P. (1987): Geochemistry of West Chilko Lake (92N/1, 8) *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1987-14.

McLaren, G.P. (1987): Geology West of Chilko Lake, Geology and Lithogeochemistry of the Chilko-Taseko Lakes Area (92N1, 8; 92O/4, 5), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1987-12.

Other Publications

McLaren, G.P. (1990): A Mineral Resource Assessment of the Chilko Lake Planning Area; *British Columbia Ministry of Energy, Mines and Petroleum Resources*; Bulletin 81.

Talks

McLaren, G.P. (1989): "Integrating Mineral Resource Data to Define Mineral Potential: The British Columbia Mineral Land Use Approach." A paper presented at the "18th Geochautaugua," Mineral Resource Assessment - Integrated Approaches; Newark, Delaware, October 1989.

Project name	WAPITI LAKE
MDA expenditures	$6,230 (1986)
Principal researcher(s)	A. LEGUN
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	NORTHEAST B.C.

OBJECTIVES To guide mineral exploration activity in the Wapiti Lake area of northeastern British Columbia by evaluating and identifying the phosphate potential. This was to be achieved through 1:50 000 scale geological mapping.

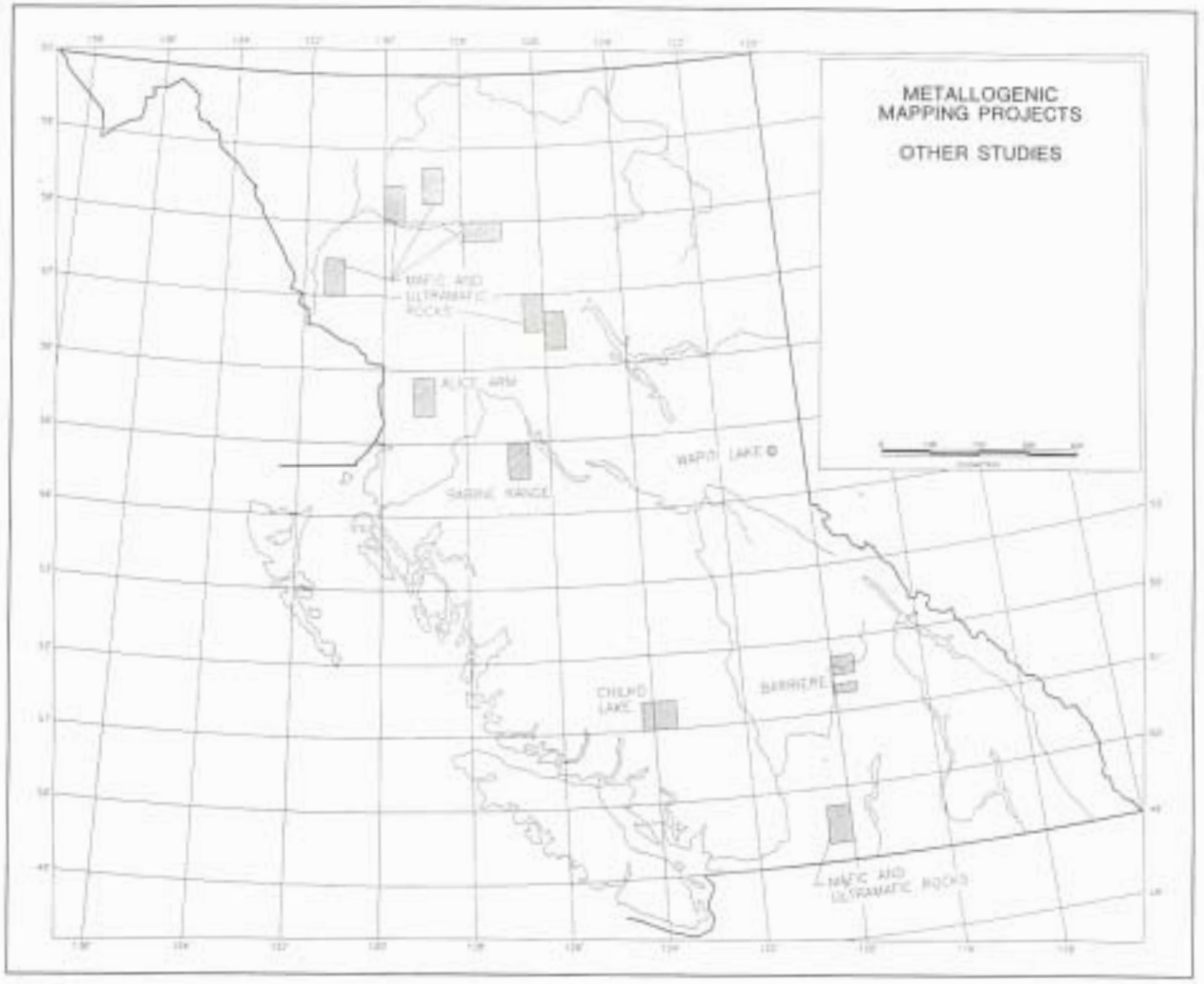
ACHIEVEMENTS Phosphatic intervals in the Sulphur Mountain Formation in the Wapati Lake area were sampled and analyzed and the regional geological setting was reviewed.

IMPACT Results from this study were incorporated into a province wide review of phosphate.

OUTPUTS

Fieldwork Articles

Legun, A. and Elkins, P. (1985): Wapiti Syncline Phosphate Potential (93J/10, 7), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1985, Paper 1986-1, pages 151-153.



Project name	MAFIC AND ULTRAMAFIC ROCKS
MDA expenditures	$417,788 (1988-1990) $40,000 (Budgeted, 1991)
Principal researcher(s)	G. NIXON
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	PROVINCE-WIDE

OBJECTIVES To generate exploration activity by studying the resource potential of the Alaskan type mafic and ultramafic rocks in British Columbia for commercially viable deposits of platinum metals, chrome, nickel, cobalt, asbestos, jade and gold. This project aimed to develop a database and establish values of platinum group elements (PGE) in a variety of rock types, as well as discover rocks with unexpected exploration potential. This was to be achieved through geological mapping at a 1:8 000 to 1:20 000 scale, geochemical sampling, isotopic dating (uranium-lead) and mineralogical analysis (electron microprobe).

ACHIEVEMENTS Detailed mapping of Alaskan-type mafic and ultramafic complexes throughout British Columbia provided a geological and geochemical database for this important class of PGE bearing intrusions. Geochemical studies identified chromitites as the principal source of PGE anomalies, and mineralogic studies related the placer concentrations of PGE with chromitite occurrences in the lode. The project defined specific targets for further evaluation by industry.

IMPACT Prospecting activity for PGE continued at a high level during the course of the project, particularly by junior companies. Public talks and poster sessions substantially increased the public's awareness of the program. The final impact of accumulated data will probably not be felt until the next phase of PGE exploration in the province.

A four year investigation examined the resource potential of Alaskan type mafic and ultramafic rocks for commercially viable deposits of platinum metals, chrome, nickel, cobalt, asbestos, jade and gold.

OUTPUTS

Fieldwork Articles

Nixon, G.T. and Rublee, V.J. (1987): Alaskan-Type Ultramafic Rocks in British Columbia: New Concepts of the Structure of the Tulameen Complex, *British Columbia Ministry of Energy, Mines and Petroleum Resources* and Ottawa-Carleton Centre for Graduate Studies, Ottawa University, Geological Fieldwork 1987, Paper 1988-1, pages 281-294.

Nixon, G.T., Ash, C.H., Connelly, J.N. and Case, G. (1988): Alaskan-Type Mafic-Ultramafic Rocks in British Columbia: The Gnat Lakes, Hickman, and Menard Creek Complexes, *British Columbia Ministry of Energy, Mines and Petroleum Resources* and Memorial University of Newfoundland, Geological Fieldwork 1988, Paper 1989-1, pages 429-442.

Nixon, G.T., Hammack, J.L. and Paterson, W.P.E. (1989): Geology and Noble Metal Geochemistry of the Johanson Lake Mafic-Ultramafic Complex, North Central British Columbia (94D/9), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1990-1, pages 417-424.

Hammack, J.L., Nixon, G.T., Wong, R.H. and Paterson, W.P.E. (1989): Geology and Noble Metal Geochemistry of the Wrede Creek Ultramafic Complex, North-Central British Columbia (94D/9), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1990-1, pages 405-415.

Nixon, G.T., Hammock, J.L., Connelly, J.N., Case, G. and Paterson, W.P.E. (1989): Geology and Noble Metal Geochemistry of the Polaris Ultramafic Complex, North Central British Columbia (94C/5, 12), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1990-1, pages 387-404.

Nixon, G.T. (1989): Geology and Precious Metal Potential of Mafic-Ultramafic Rock in British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1990-1, pages 353-358.

Open Files

Nixon, G.T. (1988): Geology of the Tulameen Ultramafic Complex, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1988-25.

Nixon, G. and Ash, C. (1989): Preliminary Geology and Noble Metal Geochemistry of the Polaris Mafic-Ultramafic Complex (94C/5 & 12), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1989-17.

Nixon G., and Ash, C. (1989): Geology and Noble Metal Geochemistry of the Turnagain Ultramafic Complex (104I/7 & 10), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1989-18.

Nixon, G.T., Hammack, J.L., Paterson, W.P.E. and Nuttall, C. (1990): Geology and Noble Metal Geochemistry of the Lunar Creek Mafic-Ultramafic Complex (94E/13 & 14), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1990-12.

Nixon, G.T., Hammack, J.L., Ash, C.H., Connelly, J.N., Case, G., Paterson, W.P.E. and Nuttall, C. (1990): Geology of the Polaris Ultramafic Complex (94C/5 & 12), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1990-13.

Hammack, J.L., Nixon, G.T., Wong, R.H., Paterson, W.P.E. and Nuttall, C. (1990): Geology and Noble Metal Geochemistry of the Wrede Creek Ultramafic Complex (94D/9), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1990-14.

Papers

Nixon, G.T. (1988): Alaskan/Ural Ultramafic Complexes in the Canadian Cordillera and the Aussie Connection. *Geological Association of Canada*, Mineral Deposits Division Newsletter, No. 26, pages 3-4.

Nixon, G.T., Cabri, L.J., and Leflamme, J.H.G. (1990): Platinum Group Element Mineralization in Lode and Placer Deposits Associated With the Tulameen Alaskan-type Complex, British Columbia. *Canadian Mineralogist*, v. 28, "Special Issue on Advances in the Study of Platinum-Group Elements." (in press).

Other Publications

Nixon, G.T., Cabri, L.J., and LaFlamme, J.H.C. (1988): Origin of Platinum Nuggets in Tulameen Placers: A Mineral Chemistry Approach with Potential for Exploration, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Exploration in British Columbia 1988, pages B83-B89.

Talks

Nixon, G.T. (1989): "Platinum and other new materials." University of Victoria, Public Lecture.

Nixon, G.T. (1990): "PGE potential of Alaskan-type ultramafic complexes in British Columbia." 4th Annual Meeting, Friends of the Igneous Rocks, Corvallis, Oregon.

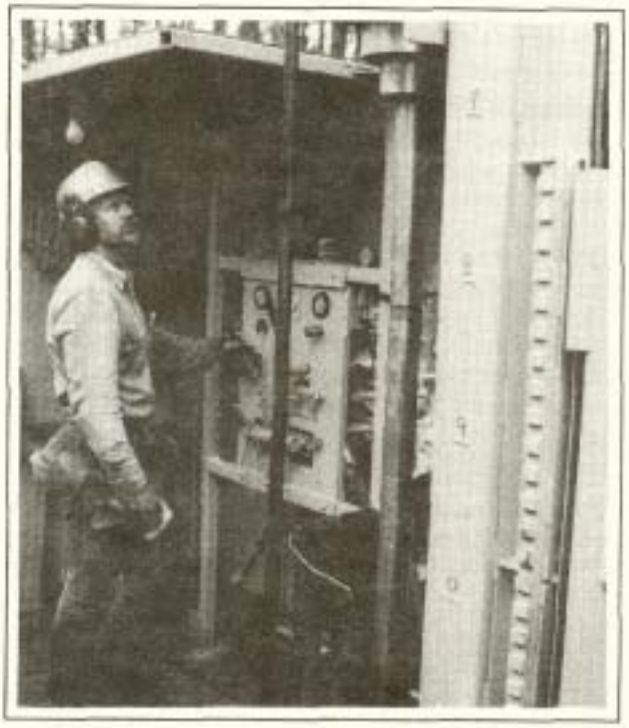
Nixon, G.T. (1990): "Geology and platinum-group element potential of Alaskan-type mafic-ultramafic complexes in British Columbia." 7th Annual Cordilleran Geology and Exploration Roundup, Vancouver, British Columbia.

Project name	**BABINE RANGE**
MDA expenditures	**$27,655 (1987)**
Principal researcher(s)	**D. MACINTYRE**
Supervising agency	**B.C. GEOLOGICAL SURVEY BRANCH**
Project location	**WEST CENTRAL B.C.**

OBJECTIVES To encourage mineral exploration in the Babine Range of west central British Columbia by developing a metallogenic model for the wide variety of mineral deposit types present in the area. This objective was to be achieved by undertaking a 1:50 000 scale mapping project in order to provide an accessible geological database for future exploration.

ACHIEVEMENTS Two 1:50 000 scale map sheets were completed. The Jurassic stratigraphy was subdivided into several mappable units. The structure of the Dome Mountain gold camp was defined. A late Cretaceous caldera was defined in the Mount Cronin area. Several new mineral occurrences were discovered during mapping.

IMPACT Detailed mapping in the Dome Mountain and Mount Cronin areas has assisted companies working in these areas with property assessments. Fault offsets of vein systems have been documented and used to predict prospective areas. New claims were staked after release of open file maps and assay data.



MDA projects have helped the B.C. mining industry stretch its dollar through better targeting of exploration funds.

OUTPUTS

Fieldwork Articles

MacIntyre, D.G., Brown, D.G., Desjardins, P. and Mallett, P. (1986): Babine Project (93L/10 & 15); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 201-218.

Open Files

MacIntyre, D., Desjardins, P., Mallett, P. and Brown, D.G. (1987): Geology of Dome Mountain Area, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1987-1.

Project name	ZIRCON SEPARATION, MICROFOSSIL SEPARATION, GEOCHEMISTRY RESEARCH, LIGHT STABLE ISOTOPES
MDA expenditures	$12,705 (1986)
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	VICTORIA AND VANCOUVER

OBJECTIVES During the first year of the MDA, these projects were undertaken to provide technical support and input into other larger projects. In later years, the costs of laboratory work were assigned to individual projects.

ACHIEVEMENTS These projects funded the laboratory work required for a number of projects. Zircon concentrates were separated and analyzed at the University of British Columbia from samples collected from the Silverton, Hedley, Alice Arm, Highland Valley and Kimberly areas. Samples from the Mount Henry Clay, Alice Arm, Clearwater, Cariboo and Hedley areas were dissolved and microfossils extracted and identified. Neutron activation analysis to determine concentrations of lanthanides (rare earth elements) was conducted on samples from north, west and central British Columbia. Light stable isotope analysis was carried out on samples from the Toodoggone precious metal camp.

IMPACT Results from these tests were incorporated into the larger projects.

University of British Columbia Mineral Research Support

Project name	SEASONAL VARIATIONS IN GOLD
MDA expenditures	$30,600 (1987-1990)
Principal researcher(s)	W.K. FLETCHER
Project location	SOUTH CENTRAL B.C. AND VANCOUVER ISLAND

OBJECTIVES To improve the design and interpretation of gold exploration geochemical surveys by investigating the sedimentological behaviour of gold particles in streams. This project intended to determine the most favorable size fraction, sample amount and site for optimum sample collection and results.

ACHIEVEMENTS As part of a broader study examining the behavior of heavy minerals in streams, the distribution and transportation of free gold in streams was studied. Results suggested that heavy mineral concentrates from bar-head gravels provided the most reliable sample sites for detecting the presence of gold in low density reconnaissance surveys. It was found that samples collected immediately after peak discharge events were the best and large amounts of material (up to 250 kg) processed in the field were necessary to obtain a representative sample. Collection of bar-head samples that were too small were found to seriously compromise the reliability of a survey. The study recommended that if it was not practical to collect adequate samples at bar-head sites, sandy sediments from bar-tail pools should be considered as an alternative. This was also determined to be the most suitable approach for follow-up surveys.

IMPACT Stream sediment geochemistry and heavy mineral surveys have routinely been used in the early stages of gold exploration in the Cordillera. However, the results of such surveys have often been extremely erratic and difficult to reproduce or confirm. The practical implications derived from this study should help to increase the reliability of these surveys.

OUTPUTS

Fieldwork Articles

Day, S. and Fletcher, K. (1986): Seasonal Variation of Gold Content of Stream Sediments, Harris Creek, Near Vernon (82L/02), The University of British Columbia and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1986, Paper 1987-1, pages 401-403.

Fletcher, W.K. and Day, S.J. (1987): Seasonal Variation of Gold Content of Stream Sediments, Harris Creek, Near Vernon: A Progress Report, The University of British Columbia and *British Columbia Ministry of En-*

ergy, Mines and Petroleum Resources, Geological Fieldwork, 1987, Paper 1988-1, pages 511-514.

Fletcher, W.K. and Zhang, W. (1989): Size Distribution of Gold in Drainage Sediments: Mount Washington, Vancouver Island (92F/14), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1988, Paper 1989-1, pages 603-605.

Open Files

Fletcher, W.K. (1990): Dispersion and Behaviour of Gold in Stream Sediments, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1990-28.

Other

Day, S.J. and Fletcher, W.K. (1986): Particle Size and Abundance of Gold in Selected Stream Sediments, Southern British Columbia, Canada, *Journal of Geochemical Exploration*, 26, pages 203-214.

Day, S.J. (1988): Sampling Stream Sediments for Gold in Mineral Exploration, Southern British Columbia, unpublished M.Sc. thesis, The University of British Columbia.

Fletcher, W.K. and Day, S.J. (1988): Behaviour of Gold and Other Heavy Minerals in Drainage Sediments: Some Implications for Exploration Geochemical Surveys, *Prospecting in Areas of Glaciated Terrain*, 1988, ed. MacDonald, D.R., Canadian Institute of Mining and Metallurgy, Halifax, Nova Scotia, pages 171-183.

Fletcher, W.K. and Horsky, S. (1988): Determination of Gold by Cyanidation and Graphite Furnace Atomic Absorption Spectroscopy, *Journal of Geochemical Exploration*, 30, pages 29-34.

Day, S.J. and Fletcher, W.K. (1989): Effects of Valley and Local Channel Morphology on the Distribution of Gold in Stream Sediments from Harris Creek, British Columbia, Canada, *Journal of Geochemical Exploration*, 32, pages 1-16.

Fletcher W.K. and Day, S.J. (1989): Behaviour of Gold and Other Heavy Minerals in Drainage Sediments: Some Implications for Exploration Geochemical Surveys, *Transactions Institute Mining and Metallurgy, Section B: Applied Earth Science*, 98, pages B130-136.

Fletcher, W.K. and Wolcott, J. (1989): Seasonal Variation in Transport of Gold in Harris Creek: Implications for Exploration, Association of Exploration Geochemists, *Explore 66*, pages 1, 8 and 9.

Day, S.J. and Fletcher, W.K. (in press): Concentrations of Magnetite and Gold ar Bar and Reach Scales in a Gravel-bed Stream, British Columbia, Canada, *Journal of Sedimentary Petrology*.

Fletcher, W.K. and Wolcott, J. (in press): Transport of Magnetite and Gold in Harris Creek, British Columbia, and Implications for Exploration, *Journal of Geochemical Exploration*.

Church, M., Wolcott, J. and Fletcher, W.K. (in press): A Test of Equal Mobility in Fluvial Sediment Transport, *Water Resources Research*.

Project name	PEACE RIVER PALYNOLOGY
MDA expenditures	$11,000 (1987-1988)
Principal researchers	J.A. BROATCH
Project location	NORTHEAST B.C.

OBJECTIVES To determine the palynologic zonation and correlation of the Peace River coalfields in northeastern British Columbia. This project intended to examine the Lower Cretaceous coal-bearing rocks in order to generate a type section to be used in interpreting, correlating and dating the section.

ACHIEVEMENTS The Lower Cretaceous coal-bearing rocks were examined for palynomorphs (terrestrial spores and pollen and marine dinoflagellate cysts). Open marine and non-marine strata were identified on the basis of palynomorph type and abundance. Contact relationships were examined and clarified. The palynologic section was compared with the lithologic section and a geologic age for the rocks was established.

IMPACT A number of groups have expressed an interest in the results of this project. These include: the Geological Survey of Canada Institute for Sedimentary and Petroleum Geology (where ongoing studies of the region are being carried out), geologists working in the Peace River coalfield (who are trying to better understand the facies distribution) and geologists throughout western Canada (who may now use the section as a basis for age comparison).

OUTPUTS

Fieldwork Articles

Broatch, J.C. (1985): Palynological Zonation and Correlation of the Peace River Coalfield, Northeastern British Columbia, The University of British Columbia and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1985, Paper 1986-1, pages 321-326.

Broatch, J. (1986): Palynological Zonation and Correlation of the Peace River Coalfield, Northeastern British Columbia: An Update, The University of British Columbia and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1986, Paper 1987-1, pages 379-382.

Broatch, J.C. (1987): A Summary of the Results of a Palynological Investigation of British Columbia's Northeast Coalfield, The University of British Columbia and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1987, Paper 1988-1, pages 451-457.

Project name	BRALORNE
MDA expenditures	$20,200 (1987-1989)
Principal researcher(s)	C. LEITCH
Project location	SOUTHWEST B.C.

OBJECTIVES To provide an updated interpretation of the geology and genesis of the Bralorne gold vein deposit in southwestern British Columbia for use by explorationists.

ACHIEVEMENTS Mapping of the Bralorne gold vein deposit was updated by using modern methods of geochronometry, geothermometry, mineralogy, thermodynamic modelling, stable isotopes, galena lead isotopes and structural analysis. The age of the mineralization and relationship to the age of other deposits was established for the first time.

IMPACT This project provided a much better understanding of the Bralorne gold vein deposit which should prove useful to the exploration industry.

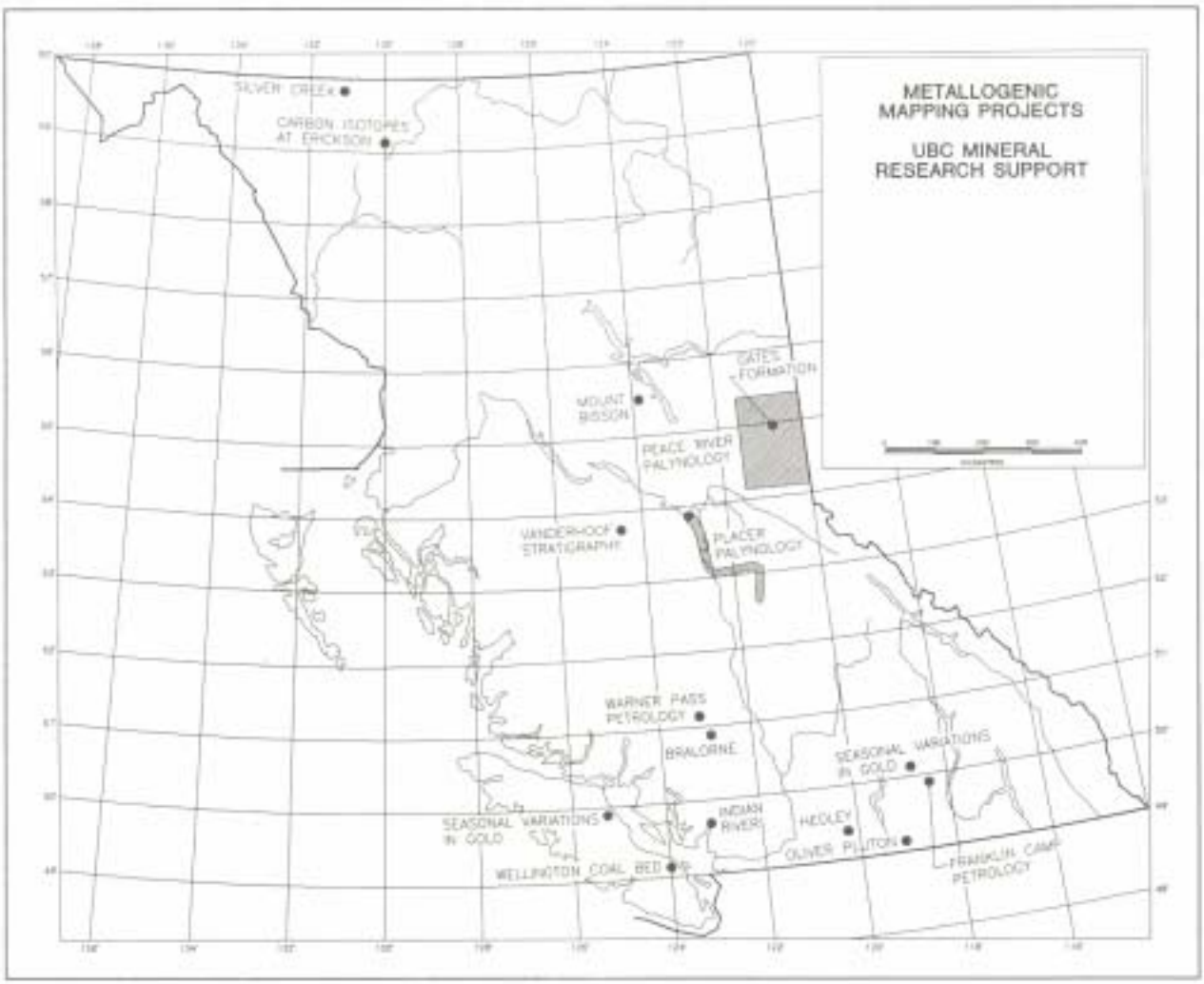
OUTPUTS

Fieldwork Articles

Leitch, C.H.B. and Godwin, C.I. (1986): The Bralorne Gold Vein Deposit: An Update (92J/15), The University of British Columbia and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1986, Paper 1987-1, pages 35-38.

Leitch, C.H.B. and Godwin, C.I. (1986): Isotopic Ages, Wallrock Chemistry and Fluid Inclusion Data from the Bralorne Gold Vein Deposit (92J/15W), The University of British Columbia and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1987, Paper 1988-1, pages 301-324.

Leitch, C.H.B., Godwin, C.I. and Brown, T.H. (1988): Characteristics of Mineralizing Fluids in the Bralorne-Pioneer Mesothermal Gold Vein Deposit: Results of a Fluid Inclusion, Stable Isotope, and Thermodynamic Study (92J/15W), The University of British Columbia and *British Columbia Ministry of Energy, Mines and*



Petroleum Resources, Geological Fieldwork, 1988, Paper 1989-1, pages 365-375.

Abstracts

Leitch, C.H.B. and Godwin, C.I. (1988): Geology of the Bralorne-Pioneer Mesothermal Gold Vein Camp, Southwestern British Columbia, Abstract in Cordilleran Section Meeting, Canadian Institute of Mining and Metallurgy, Fernie, British Columbia, November, 1988.

Leitch, C.H.B., Dawson, K.M., and Godwin, C.I. (1989): Late Cretaceous-Early Tertiary Gold Mineralization: A Galena Lead Isotope Study of the Bridge River Mining Camp, Southwestern British Columbia, Canada, Abstract in Gold Conference, Melbourne, Australia.

Other

Leitch, C.H.B. (1989): Geology, Wallrock Alteration, and Characteristics of the Ore Fluid at the Bralorne Mesothermal Gold Vein Deposit, Southwestern British Columbia, unpublished Ph.D. thesis, The University of British Columbia.

Leitch, C., Dawson, K.M., and Godwin, C.I. (1989): Early Late Cretaceous-Early Tertiary Gold of the Bridge River Mining Camp, Southwestern British Columbia, Canada, *Economic Geology*, Volume 84, pages 2226-2236.

Leitch, C.H.B., Godwin, C.I., Brown, T.H., and Taylor, B.E. (in press): Geochemistry of Mineralizing Fluids in the Bralorne-Pioneer Mesothermal Gold Vein Deposit, British Columbia Canada, *Economic Geology*.

Leitch, C.H.B., Van der Heyden, P., Godwin, C.I., Armstrong, R.L., and Harakal, J.E. (in press): Geochronology of the Bridge River Camp, including Petrochemistry of Relevant Parts of the Cadwallader and Bridge River Terranes, Southwestern British Columbia, *Canadian Journal of Earth Science*.

Displays

Leitch, C.H.B. and Godwin, C.I. (1986): Geology of the Bralorne-Pioneer Gold Deposits, Southwestern British Columbia Poster Display, Cordilleran Roundup, Vancouver British Columbia, Hotel Vancouver, January 1986.

Leitch, C., and Godwin, C.I. (1988): Geology of the Bralorne-Pioneer Mesothermal Gold Camp, Southwestern British Columbia Poster Display, Cordilleran Roundup, Hotel Vancouver, Vancouver, British Columbia, January 1988.

Leitch, C.H.B. and Godwin, C.I. (1989): Geology of the Bralorne-Pioneer Gold Camp, Southwestern British Columbia Poster Display, Cordilleran Roundup, Hotel Vancouver, Vancouver, British Columbia, February 1989 (1st place in University Poster Competition).

The MDA supported graduate student work through 19 different geoscience studies at the University of British Columbia.

Project name INDIAN RIVER

MDA expenditures $23,500 (1987-1988)
Principal researcher(s) D. REDDY
Project location SOUTHWEST B.C.

OBJECTIVES To determine the age and structural style of the volcanogenic deposits that occur in the Indian River belt of rocks in southwestern British Columbia.

ACHIEVEMENTS The geology around known deposits in the area was mapped and the mineralization was compared to that of the major Britannia mine on Howe Sound, to the Seneca deposit near Harrison Lake and to volcanogenic deposits near Whistler. Work was done to determine the age of the stratigraphy and the final results are currently being compiled. Results to date indicate changes in structural style between the Indian River belt and the overlying volcanics associated with Sky Pilot Mountain (which are known to be Cretaceous Gambier Group units), which supports a Jurassic age. Galena lead isotope analysis suggests a common age among volcanogenic deposits assigned to Harrison Lake Group and Gambier Group rocks.

IMPACT This work represents the first published, modern, detailed mapping of this area of volcanogenic deposits. It will be of interest to companies involved in exploration for volcanogenic deposits.

OUTPUTS

Fieldwork Articles

Reddy, D.G., Ross, J.V., and Godwin, C.I. (1986): Geology of the Hopkins Property, Indian River Area, Southwestern British Columbia (92G/11), The University of British Columbia and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1986, Paper 1987-1, pages 43-45.

Reddy, D.G., Ross, J.V. and Godwin, C.I. (1986): Geology of the Maggie Property, Indian River Area, Southwestern British Columbia, The University of British Columbia and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1987, Paper 1988-1, pages 295-300.

Other

Reddy, D.G. (1989): Geology of the Indian River area, Southwestern British Columbia, unpublished M.Sc. thesis, The University of British Columbia.

Displays

Reddy, D.G., Godwin, C.I., and Ross, J.V. (1989): Discrimination, Using Galena Lead Isotope Data, of Volcanogenic from Plutonogenic Deposits in Gambier Group and Spatially Related Stratigraphy, Harrison Lake to Jervis Inlet, Southwestern British Columbia, Poster Session, Cordilleran Roundup, Hotel Vancouver, Vancouver, British Columbia, February 1989.

Project name SILVER CREEK

MDA expenditures $4,000 (1987-88)
Principal researchers J. BRADFORD
Project location NORTH CENTRAL B.C.

OBJECTIVES To provide a better understanding of the Silver Creek, carbonate hosted, silver-lead-zinc-tin manto deposit in north central British Columbia by undertaking a detailed mapping program.

ACHIEVEMENTS In addition to mapping, geochronometry, sulphur isotope studies and fluid inclusion studies were completed in order to provide a modern database for genetic interpretations. The causative pluton was identified at depth, karstic control was documented and the temperature and conditions of deposition were defined within narrow limits.

IMPACT This project provided technical support to the Midway mapping project. Understanding of this type of deposit was enhanced by the work done in this study. While other such deposits are known in the province, few, including the famous Bluebell mine in the southeast, are well understood. These results should prove of benefit to the exploration industry.

OUTPUTS

Fieldwork Articles

Bradford, J.A. And Godwin, C.I. (1987): Midway Silver-Lead-Zinc Manto Deposit, Northern British Columbia (104O/16), The University of British Columbia and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1987, Paper 1988-1, pages 353-360.

Other

Bradford, J. A. (1988): Geology and Genesis of the Midway Silver-Lead-Zinc Deposit, North Central British Columbia, unpublished M.Sc. thesis, The University of British Columbia, 285 pages.

Project name WARNER PASS PETROLOGY

MDA expenditures $3,000 (1988)
Principal researcher(s) D. PAYNE
Project location SOUTHWEST B.C.

OBJECTIVES To unravel the stratigraphic, structural and geochemical relationships between spatially related felsic-intermediate volcanic rocks and the Mount Sheba intrusion.

ACHIEVEMENTS A detailed stratigraphic section and a field map were produced which clarified the nature of the

contacts and the relative ages of the mappable units. Based on the observations, the Mount Sheba igneous complex was determined to have had three distinct phases of plutonic and volcanic activity.

IMPACT This study provided technical support to the Taseko-Bridge River project. The new insights obtained regarding the character of the Mount Sheba igneous complex will be an important reference source for future work.

OUTPUTS

Fieldwork Articles

Payne, D.F. and Russell, J.K. (1987): Geology of the Mount Sheba Igneous Complex (92O/03), The University of British Columbia and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1987, Paper 1988-1, pages 125-130.

Project name **FRANKLIN CAMP PETROLOGY**

MDA expenditures **$11,600 (1988-1989)**
Principal researcher(s) **M. KEEP**
Project location **SOUTHERN B.C.**

OBJECTIVES To study the petrology of the Averill plutonic complex in the Franklin Mining Camp.

ACHIEVEMENTS The chemical and mineralogical variations to magmatic processes were documented and the findings were related to the regional tectonics of southern British Columbia. The temporal relationships between magmatic processes and mineralization were established.

IMPACT This work has been of use to explorationists working on alkaline intrusions. Since Placer Dome Incorporated relinquished its option on the property, there has been little economic interest in the project area.

OUTPUTS

Fieldwork Articles

Keep, M. and Russell, J.K. (1987): Geology of the Averill Plutonic Complex, Franklin Mining Camp (82E/9), The University of British Columbia and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1987, Paper 1988-1, pages 49-53.

Keep, M. and Russell, J.K. (1988): The Geology of the Averill Plutonic Complex, Grand Forks, British Columbia (82E/9W), The University of British Columbia and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1988, Paper 1989-1, pages 27-31.

Other

Keep, M. (1989): The Geology and Petrology of the Averill Plutonic Complex, Grand Forks, British Columbia, Unpublished Master's thesis, The University of British Columbia, 111 pages.

Project name **GALENA LEAD ISOTOPE ANALYSIS**

MDA expenditures **$27,000 (1987-1990)**
Principal researcher(s) **J. GABITES**
Project location **PROVINCE-WIDE**

OBJECTIVES To provide a better understanding of the application of galena lead isotope analyses to exploration decisions.

ACHIEVEMENTS Galena lead isotope data from mineral occurrences around the province were analyzed. It was found that more information was yielded from samples in some areas of British Columbia than in others. On a regional basis, the following information was revealed: In the Stewart-Iskut River area, Tertiary deposits could be distinguished from Jurassic deposits. In the Selwyn Basin in northeastern British Columbia SEDEX deposits could accurately be dated and distinguished from intrusive related epigenetic deposits. In the Purcell Group, sullivan type SEDEX deposits had a different lead signature than the epigenetic veins such as Vine and Moyie. In the Smithers area, galena lead isotopes were found to smear along a line that could represent lead generated by plutons.

IMPACT This project showed that in several instances the application of galena lead isotope analyses has helped to focus exploration work. Many companies currently use this technology and the British Columbia Ministry of Energy, Mines and Petroleum Resources increasingly incorporates galena lead isotope studies into their regional mapping surveys.

OUTPUTS

Fieldwork Articles

Alldrick, D.J., Gabites, J.E. and Godwin, C.I. (1986): Lead Isotope Data from the Stewart Mining Camp (104B/1), The University of British Columbia and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1986, Paper 1987-1, pages 93-102.

Godwin, C.I. and Gabites, J.E. (1986): Galena Lead Isotope Research on Mineral Deposits at the University of British Columbia, The University of British Columbia and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1986, Paper 1987-1, page 443.

Godwin, C.I. and Gabites, J.E. (1987): Galena Lead Isotope Research at the University of British Columbia, The University of British Columbia and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1987, Paper 1988-1, pages 529-530.

Andrew, A. and Godwin, C.I. (1988): Galena Lead Isotope Model for Vancouver Island, The University of British Columbia and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1988, Paper 1989-1, pages 75-79.

Godwin, C.I., Gabites, J.E., and Schroeter, T.G. (1989): Galena Lead Isotopes of the Toodoggone Epithermal Gold Camp, North Central British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 413-415.

Godwin, C.I., Pickering, A., Bradford, J., Ray, G.E., and Webster, I. (1989): Interpretation of Galena Lead Isotopes from Texada Island (82F), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1990-1, pages 271-278.

Abstracts

Godwin, C.I., Andrew, A., and Gabites, J.E. (1989): Galena Lead Isotope Models for Defining Age and Genesis of Mineral Deposits in the Canadian Cordillera, invited paper presented at the Technical Program, 28th International Geological Congress, Washington, D.C., Extended Abstracts, Volume 1 of 3, pages 1-559 - 1-560, July 1989.

Alldrick, D.J., Godwin, C.I., Gabites, J.E., and Pickering, A.D.R. (1990): Turning Lead into Gold — Galena Lead Isotope Data from the Anyox, Kitsault, Stewart, Sulphurets and Iskut Mining Camps, Northwest British Columbia, Abstract in GAC-MAC Annual Meeting, page A2, Vancouver, British Columbia, May 1990.

Gabites, J.E., and Godwin, C.I. (1990): Lead Isotope Data for Mineral Deposits in the Central Intermontane Belt, British Columbia, Abstract in GAC-MAC Annual Meeting, page A42, Vancouver, British Columbia, May 1990.

Godwin, C.I., Andrew, A., Reddy, D., Leitch, C.H.B., Gabites, J.E., and Pickering, A. (1990): Application of Galena Lead Isotope Models for Defining the Age and Genesis of Mineral Deposits in the Canadian Cordillera, Abstract in GAC-MAC Annual Meeting, page A47, Vancouver, British Columbia, May 1990.

Papers

Godwin, C.I., Gabites, J.E., and Andrew, A. (1988): Leadtable: A Galena Lead Isotope Data Base for the Canadian Cordillera, with a Guide to its Use by Explorationists, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Paper 1988-4.

Other

Andrew, A. (1987): Lead and Strontium Isotope Study of Five Volcanic and Intrusive Rock Suites and Related Mineral Deposits, Vancouver Island, British Columbia, unpublished PH.D. thesis, The University of British Columbia.

Hoy, T., and Godwin, C.I. (1988): Significance of a Cambrian Date from Galena Lead Isotope Data for the Stratiform Cottonbelt Deposit in the Manshee Complex, Southeastern British Columbia, *Canadian Journal Earth Science*, Volume 25, pages 1534-1541.

Andrew, A., and Godwin, C.I. (1989): Lead- and Strontium-Isotope Geochemistry of Paleozoic Sicker Group and Jurassic Bonanza Group Volcanic Rocks and Island Intrusions, Vancouver Island, British Columbia, *Canadian Journal Earth Science*, Volume 26, pages 894-907.

Andrew, A. and Godwin, C.I. (1989): Lead- and Strontium-Isotope Geochemistry of the Tertiary Catface Intrusions and Related Mineralization, Vancouver Island, British Columbia, *Canadian Journal Earth Science*, Volume 26, pages 920-926.

Andrew, A., and Godwin, C.I. (1989): Lead- and Strontium-Isotope Geochemistry of the Karmutsen Formation, Vancouver Island, British Columbia, *Canadian Journal Earth Science*, Volume 26, pages 908-919.

Displays

Gabites, J.E., Godwin, C.I., and Alldrick, D. (1987): Galena Lead Isotopes in the Stewart Area, Northwestern British Columbia, Poster Display, Cordilleran Roundup, Vancouver, British Columbia, Hotel Vancouver, Vancouver, British Columbia, January, 1987.

Gabites, J.E., Godwin, C.I. and Schroeter, T.G. (1988): Galena Lead Isotopes in the Toodoggone Epithermal Gold Area, North Central British Columbia Poster Display, Cordilleran Roundup, Hotel Vancouver, Vancouver, British Columbia, January 1988.

Talks

Gabites, J.E., and Godwin, C.I. (1988): "Galena Lead Isotopes in the Intermontane Belt," Central British Columbia, presented at the Smithers Exploration Group Review, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Smithers, British Columbia, October, 1988.

Andrew, A., Armstrong, R.L., and Godwin, C.I. (1989): "Lead-Strontium-Neodymium Isotope Study of Vancouver Island," Lithoprobe Workshop, The University of British Columbia, Vancouver, British Columbia, February 1989.

Godwin, C.I. (1989): "Application of Lead Isotopes in Mineral Exploration", presented at Ore Deposit Series, Geological Survey of Canada, Vancouver, British Columbia, February 14, 1989.

Godwin, C.I., Andrew, A., and Gabites, J.E. (1989): "Galena Lead Isotope Model for Paleozoic and Tertiary Deposits, Vancouver Island," British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Vancouver Island Sicker Workshop, Tally Ho Motel, Nanaimo, British Columbia, September 1989.

Project name **CONODONT DATING**

MDA expenditures **$15,500 (1988-1990)**

Principal researcher(s) **M. ORCHARD**

Project location **PROVINCE-WIDE**

OBJECTIVE To provide microfossil, particularly conodont, determinations, ages, and paleothermometry (CAI) data for the British Columbia Ministry of Energy, Mines and Petroleum Resources in support of their regional mapping projects.

ACHIEVEMENTS Approximately 500 collections were organized and assessed and curatorial, geographic, and stratigraphic data verified. Faunal, biochronologic and thermometric data, supported through the Geological Survey of Canada, were also completed. Recently, all relevant data was compiled, edited and converted into database files in preparation for publication.

IMPACT The data compiled during this project has been fundamental to many of the government's mapping projects. It has been used to compile stratigraphic sequences and delineate rock units and structures.

OUTPUTS

Fieldwork Articles

Orchard, M.J. and Irwin, S. (1987): Conodont Biostratigraphy, Midway Property, Northern British Columbia (104O/16), Geological Survey of Canada, The University of British Columbia and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1987, Paper 1988-1, pages 249-253.

Irwin, S.E.B. & Orchard, M.J. (1989): Conodont Biostratigraphy and Constraints on Upper Devonian Mineral Deposits in the Earn Group, Northern British Columbia and Yukon, *Geological Survey of Canada*, Current Research, Part E, Paper 89-1E, pages 13-19.

Project name **WELLINGTON COAL BED**

MDA expenditures **$5,000 (1989)**

Principal researcher(s) **C. BICKFORD**

Project location **VANCOUVER ISLAND**

OBJECTIVES To determine the regional geology and detailed stratigraphic framework of the Wellington coal bed. This was to be achieved through surface mapping, underground observations and borehole data analysis.

ACHIEVEMENTS Detailed geological information was compiled on the Wellington coal bed, which located, identified and collated all relevant drill records. In conjunction with a larger British Columbia Ministry of Energy, Mines and Petroleum Resources project, a 1:20 000 scale geological map of the Western Nanaimo Coal Field was produced. Selected key logs have been input into a PC computer and are now available in MS Word format from the Ministry.

A detailed geological map of the Wellington coal bed and associated rocks in the Western Nanaimo coalfield is currently being prepared and should be released as an Open File in 1991.

IMPACT As a result of this work, five companies have shown interest in the area, prompted primarily by the coal facies map in Geological Fieldwork. Two companies have investigated the potential of re-opening old mine workings and another company is currently considering a mine in an area not previously worked.

OUTPUTS

Fieldwork Articles

Bickford, C.G.C. (1988): Geology, Mining Conditions and Resource Potential of the Wellington Coal Bed, Georgia Basin (92F/1, 92G/4), The University of British Columbia and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1988, Paper 1989-1, pages 553-558.

Project name **VANDERHOOF STRATIGRAPHY**

MDA expenditures **$2,000 (1989)**

Principal researcher(s) **G. ROUSE AND W. MATHEWS**

Project location **CENTRAL B.C.**

OBJECTIVES To describe the lithologies, palynomorph assemblages and ages of core from two key drill holes in the Nechako Plateau of central British Columbia near Vanderhoof.

ACHIEVEMENTS The sediments underlying the volcanics, dated with K/Ar as Middle Eocene, proved to be

all Miocene in one well, and Miocene overlying Oligocene in the other. The palynomorph assemblages were found to correlate with those of the Australian Creek (Oligocene) and Fraser Bend (Miocene) formation near Quesnel. Overlying mid Eocene volcanics suggests overthrusting, or possibly sliding of blocks of volcanics in post-Miocene times.

IMPACT Explorationists examining the Wolf gold claims to the south and west of the project area have expressed an interest in the study results. In particular, a similar inversion of mid Eocene volcanics on Mio-Oligocene sediments has been found and a sample analysis has been requested to confirm these results.

OUTPUTS

Fieldwork Articles

Rouse, G.E. and Mathews, W.H. (1988): Palynology of Subsurface Cenozoic Sediments and Pyroclastic Rocks Southwest of Vanderhoof, British Columbia, The University of British Columbia and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1988, Paper 1989-1, pages 189-193.

Project name **MOUNT BISSON ALKALINE COMPLEX**

MDA expenditures **$6,600 (1989-1990)**
Principal researcher(s) **A. HALLERAN**
Project location **NORTHEAST B.C.**

OBJECTIVES To examine the alkaline intrusive rocks of the Manson Creek area in northeastern British Columbia for rare earth elements.

ACHIEVEMENTS Research on this project is still ongoing. The work involves characterizing the chemical compositions of the intrusions, documenting the mineralogical and mineral chemical variations within the intrusions, and developing a process related explanation for the occurrence of the REE rich igneous rocks.

IMPACT This work should prove useful because of the significant potential of these rocks to host commercial concentrations of rare earth elements.

OUTPUTS

Final report is in progress.

Project name **OLIVER PLUTON**

MDA expenditures **$6,000 (1989)**
Principal researcher(s) **U. MADER AND P. LEWIS**
Project location **SOUTHEAST B.C.**

OBJECTIVES To map the Kobau Group metamorphic rocks outcrop between the Fairview and Oliver plutons in southeastern British Columbia.

ACHIEVEMENTS A mapping program was undertaken in the Kobau group rocks. Many of the questions concerning the existence and nature of the stratigraphy within the Kobau were resolved through this project.

IMPACT The map that was produced has been used extensively by geologists working in the Fairview gold camp.

OUTPUTS

Fieldwork Articles

Mader, U., Lewis, P. and Russell, J.K. (1988): Geology and Structure of the Kobau Group Between Oliver and Cawston, British Columbia: With Notes on Some Auriferous Quartz Veins (82E/4E), The University of British Columbia and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1988, Paper 1989-1, pages 19-25.

Open Files

Louis, P., Mader, U. & Russel, J. (1989): Geology of Kobau Group Between Oliver and Cawston, British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1989-2.

Project name **CARBON ISOTOPES AT ERICKSON**

MDA expenditures **$3,000 (1989)**
Principal researcher(s) **A. SINCLAIR**
Project location **NORTH CENTRAL B.C.**

OBJECTIVES To understand the nature of carbon in gold-quartz veins and alteration zones at the Total Erickson gold mine in north central British Columbia.

ACHIEVEMENTS Carbon isotopes were used as the principal tool to investigate the origin of carbon and its place in the genetic model for the gold-quartz veins of the area. The initial isotopic study has provided strong indications that elemental carbon associated with the Total Erickson gold-quartz veins originated from carbon-bearing sedimentary strata underlying the basaltic sequence that encompasses most of the veins. The isotope ratios were found to be unusual in resembling continental carbon.

IMPACT The anomaly discovered during this study has lead to an expanded study of the carbon utilizing new X-ray diffraction equipment at the University and including extended organic geochemistry studies.

OUTPUTS

Other

Sinclair, A.J. (1988): Preliminary Isotopic Study of Carbon in Gold-Quartz Veins, Total Erickson Mine, Cassiar District, British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Exploration in British Columbia 1988, pages B169-B172.

Sinclair, A.J. & Sketchley, D.A. (in preparation): Carbonate Alteration in Basalt at Total Erickson Gold Mine, North Central British Columbia, *Journal of Economic Geology*.

Project name **PHASE DIAGRAM SOFTWARE**

MDA expenditures $3,000 (1989)
Principal researcher(s) R. BERMAN
Project location PROVINCE-WIDE

OBJECTIVES To provide an IBM-compatible computer program for the calculation of phase equilibria which could be used to understand the physiochemical controls on the formation of ore deposits.

ACHIEVEMENTS An IBM-compatible program, PTS-System, version 2.0, was developed. It is capable of calculating activity-activity, temperature-activity, and pressure-activity diagrams to elucidate ore-forming processes.

IMPACT This program has seen increased use in theoretical and applied research fields.

OUTPUTS

Fieldwork Articles

Berman, R.G. and Brown, T.H. (1988): PTA System: A Software Package for Micro-computer Calculation and Display of Activity-Temperature-Pressure Phase Diagrams, The University of British Columbia and *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1988, Paper 1989-1, pages 621-624.

Berman, R.G., Brown, T.H., and Perkins, E.H. (1989): PTA-System: A Software Package for Microcomputer Calculation and Display of Activity-Temperature-Pressure phase diagrams, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 621-624.

Project name **ULTRAMAFICS RESEARCH**

MDA expenditures $3,500 (1989)
Principal researcher(s) G. NIXON AND J. RADLOFF
Project location PROVINCE-WIDE

OBJECTIVES To investigate the mineralogy of the Polaris ultramafic complex with an emphasis on platinum group element (PGE) enriched rocks.

ACHIEVEMENTS Electron microprobe analyses of rock samples from the Polaris complex were conducted.

IMPACT The results from this project will be incorporated in the final report of the ultramafic project under the mettallogenic mapping component of the MDA.

Project name **GATES FORMATION**

MDA expenditures $9,000 (1990)
Principal researcher(s) M.N. LAMBERSON
Project location NORTHEAST B.C.

OBJECTIVE To document the factors controlling the distribution of organic facies in coals of the Gates Formation and time-equivalent strata in northeastern British Columbia. The project also intended to analyze several parameters of individual coal facies to obtain more information about coalbed methane.

ACHIEVEMENTS Samples were collected from natural outcrops, coal mine exposures and subsurface drillcore and cuttings in the Bullmoose and Quintette mine areas. The research determined that the compositional boundaries between coal facies are gradational. From bright to dull coals, a progressive decrease in vitrinite and increase in inertinite was found. Liptinite was found to be negligible (<1%). These facies appeared to represent depositional environments ranging from forest swamps to dry, herbaceous and/or shrubby marshes. Compositional variations were determined to be due to differences in plant communities, groundwater levels and proximity to active fluvial systems. Rock-Eval analysis of drill cuttings indicated that total organic carbon decreased seaward from the paleoshoreline. The bulk of the organic matter was found to be Type II (terrestrial), and overmature with respect to oil generation.

IMPACT Both the coal and petroleum industry have expressed an interest in this research. Coal companies have been particularly interested in the ability to map variations within a deposit, so that they can better predict variations in coal quality. Information about the coalbed methane resources in the province has also been requested.

OUTPUTS

Fieldwork Articles

Lamberson, M.N. and Bustin, R.M. (1988): Petrology, Sedimentology and Geochemistry of Gates Formation Coals, Northeastern British Columbia: Preliminary Results (93P/3, 4; 93I/3, 4), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 571-576.

Lamberson, M.N., Bustin, R.M., Kalkreuth, W.D., and Pratt, K.E. (1989): Lithotype Characteristics and Variation in Selected Coal Seams of the Gates Formation, Northeastern British Columbia (93:/3), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1990-1, pages 461-468.

Papers

Lamberson, M.N., Kalkreuth, W., and Bustin, R.M. (1989): Petrology and Sedimentology of Gates Formation Coals, Northeastern British Columbia: Preliminary Results, in, *Contributions to Canadian Coal Geoscience, Geological Survey of Canada*, Paper 89-8, pages 88-95.

Abstracts

Lamberson, M.N., Kalkreuth, W.D., Bustin, R.M. and Pratt, K.C. (1989): Lithotype Variation in Lower Cretaceous (albian) Gates Formation Coal Seams, Northeastern British Columbia, Canada, Abstracts with Program, The Society for Organic Petrology, Sixth Annual meeting Urbana, Illinois, 1989.

Lamberson, M.N. and Bustin, R.M. (1990): Coal Lithotype Composition and Variation: Gates Formation, Northeastern British Columbia (poster), Abstracts with Program, The Society for Organic Petrology, Seventh Annual Meeting, page 82, Calgary, Alberta, 1990.

Calder, J.H., Kalkreuth, W., Lamberson, M.N., Marchioni, D.L., and Naylor, R.D. (1990): The Relationship between Coal Petrography and Depositional Environments: A Status Report on Canadian Research, Abstracts with Program, The Society for Organic Petrology, Seventh Annual Meeting, page 29, Calgary, Alberta, 1990.

Lamberson, M.N. and Bustin, R.M. (1990): Organic Facies Variations within the Lower Cretaceous Gates Formation, Northeastern British Columbia, Proceedings Volume, Geological Association of Canada - Mineralogical Association of Canada, Annual Meeting Vancouver, British Columbia, May 16-18, 1990.

Other

Lamberson, M.N., Kalkreuth, W.D., and Bustin, R.M. (in press): Lithotype Composition and Variation in Selected Coal Seams of the Gates Formation, Northeastern British Columbia, Canada, *International Journal of Coal Geology*.

Talks

Presentations were made at the following:

- Poster Session, British Columbia and Yukon Chamber of Mines Cordilleran Roundup, Vancouver British Columbia, 1989.
- "Characteristics of Gates Formation Coal Seams, Northeastern British Columbia," (Research in Progress) Tri-University Conference, University of British Columbia, March 1989.
- The Society for Organic Petrology annual Meeting, Urbana, Illinois, October 1989.
- British Columbia and Yukon Chamber of Mines Cordilleran Roundup, Vancouver, British Columbia, February 1990 (first prize in student poster competition).
- joint meeting of the Canadian Coal Petrographers Group and the Society for Organic Petrology, Calgary, Alberta, September 1990.

Project name	PLACER PALYNOLOGY
MDA expenditures	$10,000 (1990)
Principal researcher(s)	G. ROUSE
Project location	SOUTH CENTRAL B.C.

OBJECTIVES To distinguish and date the various placer gold deposits in the Quesnel-Prince George area by using palynological analysis.

ACHIEVEMENTS A number of samples were collected from the old Bullion mine in the south, near Likely, through the Barkerville-Wells region, to the Cottonwood River-Quesnel-Prince George area. To date, all of the samples were determined to contain palynolassemblages of Tertiary age, corresponding to those from the Fraser Bend formation. Questions were raised as to whether some samples which appeared to be from mid-late Pleistocene glacial or postglacial events were really of Tertiary age, associated with later Tertiary-early Pleistocene glaciations.

IMPACT Several geologists working with placer deposits have expressed an interest in this project and future cooperative ventures are planned.

OUTPUT

Rouse, G.E., Lesack, K.A., & Hughes, B.L. (1989): Palynological Dating of Sediments Associated with Placer Gold Deposits in the Barkerville-Quesnel-Prince George Region, South Central British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Field work 1989, Paper 1990-1, pages 531-532.

Project name	HEDLEY
MDA expenditures	$14,000 (1990)
Principal researcher(s)	G. DAWSON
Project location	SOUTH CENTRAL B.C.

OBJECTIVES To provide more detailed knowledge on the Good Hope and French deposit areas in the Hedley gold skarn camp. This project intended to expand on the framework provided by the earlier British Columbia Ministry of Energy, Mines and Petroleum Resources project examining the Hedley camp.

ACHIEVEMENTS Detailed mapping and petrography of the Good Hope-French deposits revealed that the Hedley camp was a classical sediment sill complex. At the French mine, it appeared that the sill complex was intimately related to the development of the gold skarn.

IMPACT The new genetic parameters provided by the sediment-sill complex offers new exploration insight into the understanding of skarn mineralization in the Hedley camp and to the understanding of many other important skarn districts.

OUTPUT

Fieldwork Articles

Dawson, G.L., Godwin, C.I., Ray, G.E., Hammack, J., and Bordin, D. (1990): Geology of the Good Hope - French Mine Area, South Central British Columbia (92H/8), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1990-1, (in press).

Abstracts

Dawson, G.L., Godwin, C.I., and Ray, G.E. (1990): Gold Skarn Mineralization Associated with a Sediment Sill Complex, French Mine, South Central British Columbia, Abstract in GAC-MAC Annual Meeting, page A30, Vancouver, British Columbia, May 1990.

1.1.4 Industrial Minerals

Project name	DIMENSION STONE
MDA expenditures	$25,594 (1986-1987)
Principal researcher(s)	G.V. WHITE
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	PROVINCE-WIDE

OBJECTIVES To promote the dimension stone industry in British Columbia. This project intended to increase industry awareness of the availability of dimension stone in the province and identify deposits with good physical properties and excellent development potential.

ACHIEVEMENTS Thirty formerly producing dimension stone quarries or prospects were examined for their development potential. A promotional information circular was produced that illustrates the quality and variety of dimension stone available from quarries throughout the province. Several local buildings that used British Columbia dimension stone in construction were pictured.

IMPACT Since the project started, one intermittent and two permanent quarry operations have started production. Another company has prepared a business plan to build a processing plant along with operating a quarry. Plans have also been initiated to develop two new quarries.

Numerous overseas business inquiries have been received by the British Columbia Ministry of Energy, Mines and Petroleum Resources regarding dimension stone in British Columbia. As a result of this project, the Ministry has been able to respond to these requests by providing good quality information.

OUTPUTS

Fieldwork Articles

White, G.V. (1986): Dimension Stone Quarries in British Columbia; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 309-342.

Other

White, G.V. and Hora, Z.D. (1988): British Columbia Dimension Stone; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Information Circular 1988-6.

Long term diversification options for the B.C. mining industry were explored in twelve industrial mineral studies.

White, G.V. (1985): Dimension Stone Quarries in British Columbia; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Exploration in British Columbia 1985, page B21-B30.

Talks

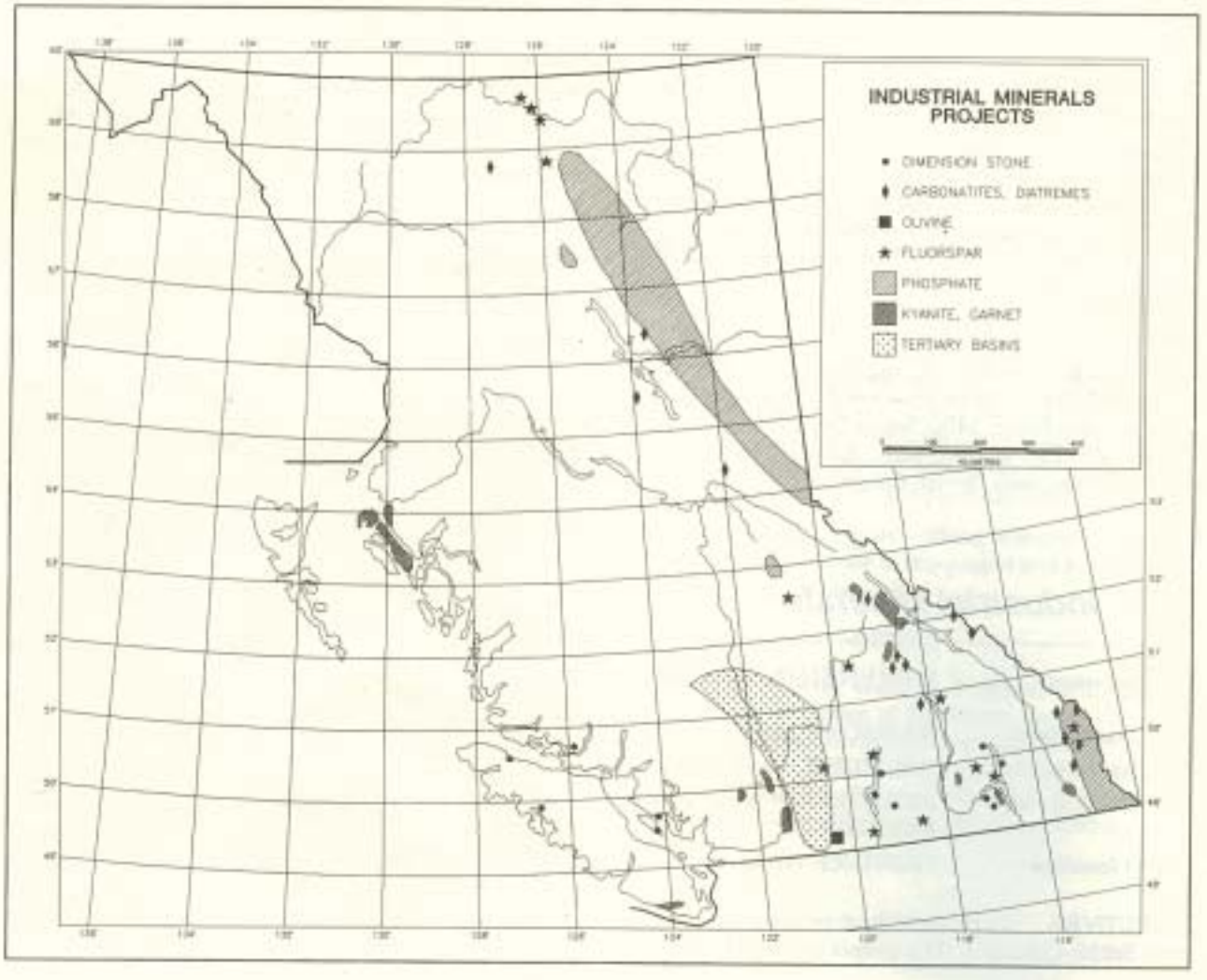
Presentations were made at the following:

- Industrial Mineral Symposium in Portland, Oregon, 1987.
- Canadian Institute of Mining and Metallurgy Meeting in Toronto, Ontario, 1987.
- Industrial Minerals Advisory Committee Meeting in Vancouver, British Columbia, 1987.

A presentation was also made to a representative of the Japanese dimension stone industry, in Victoria, British Columbia, 1990.

Project name	**CARBONATITES AND KIMBERLITES**
MDA expenditures	**$73,031 (1986-1988)**
Principal researcher(s)	**J. PELL**
Supervising agency	**B.C. GEOLOGICAL SURVEY BRANCH**
Project location	**CENTRAL AND EASTERN B.C.**

OBJECTIVES To stimulate industry interest in the industrial mineral potential of carbonatites, nepheline syenites and kimberlites in British Columbia by identifying favourable areas for exploration. This objective was to be achieved by documenting known occurrences of carbonatites, kimberlites and related rocks in terms of geology, petrology, geochemistry and geochronology. The tectonic and geologic controls on the emplacement of these bodies was also to be established.



ACHIEVEMENTS Mapping or sampling of 12 carbonatite/syenite intrusions/complexes and 11 diatremes or diatreme swarms was completed. At least 3 of the carbonatites were identified as having significant economic potential: the Aley for niobium, Rock Canyon Creek for fluorspar and rare earth elements and the Kechika prospect for yttrium and rare earth elements. Trident Mountain syenite was found to have some economic interest with respect to nepheline syenite. A tectonic model was established for the emplacement of these bodies which relates to rifting on the ancient continental margin. Favourable areas for exploration were outlined.

IMPACT This project generated significant interest from academia, exploration companies and prospectors. All copies of the Open File report were sold. During the life of the project, a fair amount of exploration work took place and at least two new occurrences were found by private sector companies. This project encouraged industry to undertake the following work: Chevron Minerals Limited to study the Bison Mountain showings, Formosa Resources to examine the Kechika River area, and Teck Corporation to consider the Wicheeda Lake showings. As well, Trident Mountain nepheline syenite was staked and sampled and US Borax Limited expressed an interest in the nepheline syenite.

OUTPUTS

Fieldwork Articles

Hoy, T. and Pell, J. (1985): Carbonatites and Associated Alkalic Rocks, Perry River and Mount Grace Areas, Shuswap Complex, Southeastern British Columbia (82M/7, 10); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1985, Paper 1986-1, pages 69-87.

Pell, J. (1985): Diatreme Breccias in British Columbia (82G, J, & N; 83C; 94B); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1985, Paper 1986-1, pages 243-253.

Pell, J. (1985): Nepheline Syenite Gneiss Complexes in British Columbia (82M, & N; 83D; 93I); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1985, Paper 1986-1, pages 255-260.

Pell, J. (1985): Carbonatites in British Columbia: The Aley Property (94B/5); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1985, Paper 1986-1, pages 275-277.

Pell, J. and Hora, Z.D. (1986): Geology of the Rock Canyon Creek Fluorite/Rare Earth Element Showing, Southern Rocky Mountains (82J/3E); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 255-258.

Pell, J. (1986): Alkalic Ultrabasic Diatremes in British Columbia: Petrology, Geochronology and Tectonic Significance (82G, J, & N; 83C; 94B); *British Columbia Ministry of Energy, Mines and Petroleum Resources*. Geological Fieldwork 1986, Paper 1987-1, pages 259-272.

Ijewliw, O.J. (1986): Comparative Mineralogy of Three Ultramafic Breccia Diatremes in Southeastern British Columbia: Cross, Blackfoot and HP (82J, 82G, & 82N); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 273-282.

Ijewliw, O.J. and Schulze, D.J. (1987): The HP Pipe, A Preliminary Report (82N/10); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, pages 369-374.

Pell, J., Culbert, R. and Fox, M. (1988): The Kechika Yttrium and Rare-Earth Prospect (94L/11, 12 and 13); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 417-421.

Open Files

Pell, J. (1987): Alkaline Ultrabasic Rocks in British Columbia: Carbonatites, Nepheline Syenites, Kimberlites, Ultramafic Lamprophyres and Related Rocks, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1987-17.

Other

Pell, J. and Simony, P.S. (1987): "New Correlations of Hadryian Strata, South-central British Columbia." *Canadian Journal of Earth Sciences*. February 1987, Vol. 24, pages 302-313.

Ijewliw, O.J. and Schulze, D.J. (1988): The Golden Cluster of Diatremes and Dykes; *British Columbia Ministry of Energy, Mines and Petroleum Resources*; Exploration in British Columbia, 1988, pages B39-B46.

Pell, J. and Hoy, T. (1989): "Carbonatites in a Continental Margin Environment - The Canadian Cordillera" in *Carbonatites: Genesis and Evolution*. K. Bell, editor, Allen & Unwin, London, pp. 200-220.

Pell, J. (in press): The Geology, Geochemistry and Economic Potential of Carbonatites, Nepheline Syenite, Kimberlites and Related Rocks in British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Bulletin.

Talks

Pell, J. (1985): "An Overview of Carbonatite Localities in British Columbia and Their Relative Economic Potential. Paper presented at the Canadian Institute of Mining and Metallurgy 1985 Vancouver, British Columbia, meeting.

Pell, J. (1986): "Diatremes of Kimberlitic Affinity in British Columbia: Diamond Potential." Paper presented at the Canadian Institute of Mining and Metallurgy 1986 Montreal, Quebec, meeting.

Pell, J. (1986): "Carbonatites in British Columbia: A Review," Paper presented to the Geological Association of Canada, in Ottawa, Ontario.

Presentations were also made at the following:

- Cordilleran Workshop, 1985, 1986 and 1987.
- Geological Association of Canada Annual Meeting in Montreal, Quebec, 1989.
- Canadian Institute of Mining and Metallurgy Meeting in Vancouver, British Columbia, 1986.
- Canadian Institute of Mining and Metallurgy Meeting in Toronto, Ontario, 1987.
- Kootenay Exploration and Mining Conference in Nelson, British Columbia, 1989.
- Canadian Institute of Mining and Metallurgy Meeting in Ottawa, Ontario, 1990.
- 8th International Association for the Genesis of Ore Deposits Symposium in Ottawa, Ontario, 1990.

Project name	OLIVINE
MDA expenditures	$9,599 (1987-1988)
Principal researcher(s)	G.V. WHITE AND Z.D. HORA
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	SOUTHEAST B.C.

OBJECTIVES To encourage industry interest in the economic potential of olivine. This objective was to be achieved by identifying possible commercial reserves of foundry-grade olivine in the Tulameen ultramafic complex near Princeton and assessing market opportunities.

ACHIEVEMENTS The geological investigation identified three zones of relatively unaltered dunite. Bulk samples were collected for tests by CANMET who found the olivine specifications to be satisfactory for most foundry sand applications. A preliminary market study identified modest markets with potential to expand subject to the development of new applications of olivine's unique thermal characteristics.

IMPACT Private sector companies began or intensified exploration for olivine in the Tulameen area. One company, Dia Met Minerals Limited, undertook a diamond drilling program on its claims in the study area. Another company began to examine the possibility of an olivine by-product, indicating an improved awareness of olivine's development potential.

OUTPUTS

Fieldwork Articles

White, G.V. (1986): Olivine Potential in the Tulameen Ultramafic Complex Preliminary Report (92H/10); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 303-307.

Hora, Z.D. and White, G.V. (1987): The Evaluation of Olivine Sand Prepared from Tulameen Dunite; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1987, Paper 1988-1, pages 381-383.

Other

Szabo, E.I. and Kular, A.C. (1987): "Evaluation of Olivine Type Sand Sample for Foundry Use." CANMET REPORT PMRL 87-20, unpublished manuscript.

D. G. Lobdell Consulting (1988): "Cursory Examination of Market Conditions for Olivine." An internal report prepared for the British Columbia Ministry of Energy, Mines and Petroleum Resources.

Talks

White, G.V. and McKillop, G. (1988): "Feldspar and Olivine - Two Potential Commodities for British Columbia." A Paper presented at the 1988 Annual General Meeting of the Canadian Institute of Mining and Metallurgy, Edmonton, Alberta, May 9, 1988.

A presentation was made at the Kootenay Exploration and Mining Conference in Nelson, British Columbia, 1989.

Project name	TERTIARY BASINS
MDA expenditures	$218,488 (1987-1990)
Principal researcher(s)	P. READ AND Z.D. HORA
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	SOUTH CENTRAL B.C.

OBJECTIVES To encourage and stimulate private sector exploration for industrial minerals by identifying favourable areas for deposits of kaolin, ceramic clays, bentonite, zeolites, pozzolanic materials, diatomite, germanium and beryllium in Tertiary volcano - sedimentary basins in southern British Columbia.

ACHIEVEMENTS A better understanding of the Tertiary stratigraphy and lithology of the area was achieved. Mapping identified and documented: zeolite, kaolin, bentonite, perlite volcanic glass, and diatomaceus earth occurrences in the Tertiary basins of southern British Columbia. A deposit model with potential exploration targets for residual kaolin and bentonite was developed. The project also discovered that certain drainage patterns established in the Eocene period had implications for current placer gold exploration.

IMPACT Interest in zeolites has developed from this project and research has been undertaken at the University

of Guelph regarding its use in fertilizer production. Occurrences identified by the project's mapping have since been staked. Many inquiries about the project's outcome have been received by the Ministry of Energy, Mines and Petroleum Resources from sources in Ontario and Alberta. Proposals are under consideration to study zeolites for water effluent treatment and other industrial uses.

OUTPUTS

Fieldwork Articles

Read, P.B. (1986): Industrial Minerals in Some Tertiary Basins Southern British Columbia (92H, 92I); Geotex Consultants Limited, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 247-254.

Read, P.B. (1987): Industrial Minerals in Tertiary Rocks, Lytton to Gang Ranch, Southern British Columbia (92I/05, 12, 13: 92O/01, 08: 92P/04), Geotex Consultants Limited, *British Columbia Ministry of Energy, Mines and Petroleum Resources*; Geological Fieldwork 1987, Paper 1988-1, pages 411-416.

Read, P.B. (1987): Industrial Minerals in the Tertiary of the Bonaparte to Deadman River Area, Southern British Columbia (92I/14, 15; 92P/02, 03), Geotex Consultants Limited, *British Columbia Ministry of Energy, Mines and Petroleum Resources*; Geological Fieldwork 1987, Paper 1988-1, pages 417-420.

A four year study identified zeolite, kaolin, bentonite, perlite, volcanic glass and diatomaceus earth occurrences in the Tertiary basins of southern B.C.

Read, P.B. (1988): Miocene Stratigraphy and Industrial Minerals, Bonaparte to Deadman River Area, Southern British Columbia (92I/14, 15; 92P/2, 3), Geotex Consultants Limited, *British Columbia Ministry of Energy, Mines and Petroleum Resources*; Geological Fieldwork 1988, Paper 1989-1, pages 515-518.

Green, K.C. and Trupia, S. (1988): Structure, Stratigraphy and Industrial Minerals in the Gang Ranch Area, Southern British Columbia (92O/8, 9), University of Calgary, *British Columbia Ministry of Energy, Mines and Petroleum Resources*; Geological Fieldwork 1988, Paper 1989-1, pages 519-524.

Marcille, V.V. (1988): Industrial Zeolites in the Princeton Basin (92H); University of Guelph, Guelph, Ontario and *British Columbia Ministry of Energy, Mines and Petroleum Resources*; Geological Fieldwork 1988, Paper 1989-1, page 511-514.

Open Files

Read, P. (1987): Tertiary Stratigraphy and Industrial Minerals, Princeton and Tulameen Basins, British Columbia, (92H/2, 7, 8, 9, 10), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1987-19.

Read, P.B. (1988): Tertiary Stratigraphy and Industrial Minerals, Merritt Basin, Southern British Columbia (92I/1, 92I/2); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1988-15.

Read, P.B. (1988): Tertiary Stratigraphy and Industrial Minerals: Fraser River, Lytton to Gang Ranch, British Columbia (92I/05, 12, 13; 92O/01, 08,; 92P/04), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1988-29.

Read, P.B. (1988): Tertiary Stratigraphy and Industrial Minerals, Cache Creek (92J/14), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1988-30.

Read, P.B. (1989): Tertiary Stratigraphy and Industrial Minerals, Bonaparte to Deadman Rivers, (92P/2, 3), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1989-21.

Read, P.B. (1990): Cretaceous and Tertiary Stratigraphy and Industrial Minerals, Hat Creek, Southern British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*; Open File 1990-23.

Other

Read, P.B. (in press): Bulletin.

Talks

A presentation was made at the 1990 Joint Meeting of the Geological Association of Canada and the Mining Association of Canada, Vancouver, British Columbia.

Project name	PHOSPHATE
MDA expenditures	$152,379 (1987-1989)
Principal researcher(s)	S. BUTRENCHUK
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	SOUTHEAST AND NORTHEAST B.C.

OBJECTIVES To stimulate industry interest in the economic potential of phosphate in British Columbia. This objective was to be achieved by identifying the most promising areas for developing phosphate deposits in the province and by compiling a resource potential for phosphate.

ACHIEVEMENTS Geological investigations identified several stratigraphic horizons containing sedimentary phosphate deposits. Of these, the Fernie Formation and Sulphur Mountain Formations were identified as affording the best potential for developing a commercial phosphate deposit in British Columbia. The Fernie Formation was estimated to have a resource potential of 57 to 340 million tonnes and the Sulphur Mountain Formation, an estimated 19 to 113 million tonnes. Also, the Aley carbonatite was recognized as possibly providing an alternative source of phosphate in the province.

IMPACT Due to poor fertilizer markets and an oversupply of phosphate worldwide, private sector interest in exploring for phosphate has been relatively low. The project , however, identified yttrium values in the Fernie phosphate which has resulted in two field programs by Formosa Resources to date. Westroc Resources has also staked some ground. As well, in research at the University of Guelph the Fernie phosphate is being used to develop a low cost, slow release fertilizer. Industry interest in the project was sufficiently high that all Open File publications on phosphate were sold out.

OUTPUTS

Fieldwork Articles

Butrenchuk, S.B. (1986): Phosphate Inventory (82G & J); *British Columbia Ministry of Energy, Mines and Petroleum Resources*; Geological Fieldwork 1986, Paper 1987-1, pages 289-302.

Butrenchuk, S.B. (1987): Phosphate Inventory: Northeastern British Columbia; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, pages 397-410.

Marcille-Kerslake, V. (1989): Sedimentary Phosphates in the Fernie Basin: Development of New Technology for Direct Application to Soils (82G and 82J); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1990-1, pages 489-492.

Open Files

Butrenchuk, S.B. (1987): Phosphate in Southern British Columbia (82G and 82J), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1987-16

Other

Butrenchuk, S.B. (in press): Phosphate Deposits in British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*; Paper.

Talks

Butrenchuk, S.B. (1988): "Petrology and Geochemistry of Phosphate Deposits in British Columbia." A Paper presented at the 1988 Annual General Meeting of the Canadian Institute of Mining and Metallurgy, Edmonton, Alberta, 1988.

Presentations were also made at the following:

- Canadian Institute of Mining and Metallurgy Meeting in Fernie, British Columbia, 1988.
- Kootenay Exploration and Mining Conference in Nelson, British Columbia, 1989.

Project name	ALEY CARBONATITE
MDA expenditures	$5,100 (1987)
Principal researcher(s)	U. MADER
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH AND THE UNIVERSITY OF BRITISH COLUMBIA
Project location	NORTHEAST B.C.

OBJECTIVES To stimulate industry interest in carbonatites and kimberlites in British Columbia by describing the geology and mineralogy of the Aley carbonatite. This project was intended to contribute to the larger study being undertaken on carbonatites and kimberlite related diatremes.

ACHIEVEMENTS The geological study identified economic minerals present in the deposit, contents of thorium in selected samples and identified rare earth elements in the individual phases of the carbonatite plug and associated dykes.

IMPACT This project resulted in increased industry awareness of the economic potential of carbonatites and related ultra-alkaline rocks in British Columbia. As a result, one company, Teck Corporation, carried out work in the Wicheeda Lake area north of Prince George and on REN claims at Perry River. Also, activities in the Kechika River area have been in part inspired by this project.

OUTPUTS

Fieldwork Articles

Mader, U.K. (1986): The Aley Carbonatite Complex, Northern Rocky Mountains, British Columbia (94B/5), University of British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*; Geological Fieldwork 1986, Paper 1987-1, Pages 283-288.

Project name	KYANITE AND GARNET
MDA expenditures	$17,278 (1988)
Principal researcher(s)	J. PELL
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	PROVINCE-WIDE

OBJECTIVES To assist industry by identifying exploration targets for kyanite and garnet in schists and other related environments in central British Columbia.

ACHIEVEMENTS An extensive literature search identified areas of high grade garnet and kyanite. Ten 1:250 000 geological maps were compiled of areas underlain by greater than 15% kyanite or greater than 25% garnet host rocks. A comprehensive bibliography on garnet, kyanite, andalusite and sillimanite in British Columbia was prepared.

IMPACT This project has generated interest from prospectors and industry, particularly regarding garnet. One company is currently in the process of developing a garnet deposit near Penticton. Exploration and drilling have been undertaken near Revelstoke. Two other areas have also been considered for exploration. As well, a potential garnet resource on Vancouver Island is being evaluated.

OUTPUTS

Fieldwork Articles

Pell, J. (1987) The Industrial Mineral Potential of Kyanite and Garnet in British Columbia, University of British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, pages 421-425.

Open Files

Pell, J. (1988): Industrial Mineral Potential of Kyanite and Garnet in British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1988-26.

Project name	PEAT INVENTORY
MDA expenditures	$12,641 (1988)
Principal researcher(s)	D. MAYNARD
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	PROVINCE-WIDE

OBJECTIVES To assess the economic potential of British Columbia peatlands in order to provide guidance to investors interested in developing a viable peat industry. This was to be achieved by compiling information on the distribution and quality of peat resources in the province from information in published and unpublished landform and soil studies.

ACHIEVEMENTS A total of 73 map sheets at a scale of 1:250 000 were produced to display information on distributions of peat deposits. The report identified three peatland resource areas: central and north coast, central Interior Plateau and northeastern Great Plains. The potential for horticultural peat was identified for both the northeastern and the northwestern part of the province. Fuel peat potential was identified for all three main regions. Agricultural uses of peatlands were found to be common in the Fraser Valley, eastern Vancouver Island, the central Interior and Peace River area. The environmental concerns of developing a peatland were also considered.

IMPACT The project stimulated industry interest in the peat resources of British Columbia. Two private companies, both from out of province, requested preliminary information on the project's conclusions. Also, the Provincial Ministries of Agriculture and Environment were interested in the project outcome and final report.

OUTPUTS

Open Files

Maynard, D.E. (1988): Peatland Inventory of British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1988-33.

Project name	TALC ASSESSMENT
MDA expenditures	$10,417 (1988)
Principal researcher(s)	M. MACLEAN
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	PROVINCE-WIDE

OBJECTIVES To aid prospectors and industry in the discovery and development of British Columbia talc to replace the imported product that is widely used in the province's pulp and paper industry. This objective was to be achieved by compiling an inventory of known talc

occurrences in British Columbia and providing information and references to act as useful guides to exploration.

ACHIEVEMENTS A report documenting 38 talc occurrences and 4 pyrophyllite occurrences was prepared. A map was compiled demonstrating the distribution of occurrences classified on the basis of host lithology. The majority of occurrences were found to be associated with schists and ultramafics of Mississippian to Triassic and Cambrian to Mississippian formations (Cache Creek, Anarchist, Sylvester, Antler and Lardeau). Two properties recently studied in detail were identified as having commercial quality talc.

IMPACT Considerable industry interest was stimulated by this project and a number of copies of the report were sold. One company, Pacific Talc Incorporated, is currently preparing plans to bring its Nahatlach River deposit to the production stage. Pacific Talc's activities brought inquiries from major talc producers in North America: Talc Luzenac Incorporated, Cyprus Minerals, US Borax, Montana Talc, and ECC International.

OUTPUTS

Open Files

MacLean, M. (1988): Talc and Pyrophyllite in British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1988-19.

Project name	FLUORSPAR POTENTIAL
MDA expenditures	$51,310 (1989)
Principal researcher(s)	Z.D. HORA
Supervising agency	B. C. GEOLOGICAL SURVEY BRANCH
Project location	PROVINCE-WIDE

OBJECTIVES To encourage and stimulate private sector exploration for fluorspar resources in British Columbia. This objective was to be accomplished by compiling a database of fluorspar resources in the province and identifying areas favourable for exploration and development. The project also intended to examine the potential of using fluorine as a pathfinder for high-tech elements, such as rare earth elements, beryllium, yttrium, and zircon.

ACHIEVEMENTS This project identified several of the criteria for distribution of fluorspar deposits in the British Columbia Cordillera Region. Geochemical studies were undertaken which used fluorine anomalies as pathfinders for high-tech elements. The potential of fluorspar deposits in British Columbia was assessed and benchmark deposit types described.

IMPACT As a result of this project, two junior companies independently assessed the potential of the Rexspar deposit. As well, the Mineral Policy Branch of Energy, Mines and Resources Canada is currently studying the feasibility of developing a British Columbia fluorspar resource for use in the Pacific northwest aluminium industry.

OUTPUTS

Fieldwork Articles

Pell, J. and Fontaine, J. (1988): Fluorspar in British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 469-482.

Pell, J., Culbert, R. and Fox, M. (1988): The Kechika Yttrium and Rare-earth Prospect (94L/11, 12 and 13), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pages 417-422.

Other

Pell, J. (1990): Open file report in press.

Pell, J. and Hora, Z.D. (in press): High-tech elements information circular.

Talks

A presentation was made on high-tech elements potential in British Columbia to the Kootenay Exploration and Mining Conference, in Nelson, British Columbia, 1989.

Project name	LIMESTONE AND DOLOMITE
MDA expenditures	$23,456 (1990)
Principal researcher(s)	P. FISCHL
Supervising agency	B. C. GEOLOGICAL SURVEY BRANCH
Project location	PROVINCE-WIDE

OBJECTIVES To promote the development of limestone and dolomite resources by compiling an inventory of present and past producers and geological units with favourable potential.

ACHIEVEMENTS This project produced the first comprehensive inventory of limestone resources in British Columbia. Geological units with limestone and dolomite resources were described and data on their chemical composition was compiled.

IMPACT Several potential gold producers have used the preliminary data from this project to search for limestone sources for use in neutralizing mine waste waters. Three major companies: Asarco Incorporated, J.M. Huber Corporation, and Ash Grove Cement West Incorporated, are using the study results to look for opportunities to open new quarries As well, smaller groups, mainly from Alberta and Eastern Canada, have used the information to assess the feasibility of a developing a new lime production facility.

OUTPUTS

Open Files

Fischl, P. (in press): Open File report.

Project name	BARITE
MDA expenditures	$28,269 (1990)
Principal researcher(s)	S. BUTRENCHUK
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	PROVINCE-WIDE

OBJECTIVES To stimulate development of British Columbia's barite resources by producing an inventory of barite occurrences in the province, which would include an assessment of the deposits and a listing of potential uses in industrial applications.

ACHIEVEMENTS An inventory was prepared which classified barite deposits and occurrences by size, potential and deposit type. Some previously undocumented barite deposits were described.

IMPACT Mountain Minerals Limited is using the preliminary results from this project to search for barite resources in order to replace the limited reserves left in the Parson deposit.

OUTPUTS

Open Files

Butrenchuk, S. (in press): Open File report.

1.1.5 Geophysics

Geophysical Surveys - surveys wherein local variations in specific geophysical parameters, such as the earth's magnetism, are measured in a systematic manner to determine distributions that may be interpreted to locate subsurface geological features, including ore deposits.

Project name	AEROMAGNETIC SURVEYS
MDA expenditures	$625,000 (1987-1989)
Supervising agency	GEOLOGICAL SERVICES OF CANADA, GEOPHYSICS DIVISION, AEROMAGNETIC SURVEYS
Project location	STRAIT OF GEORGIA, CENTRAL VANCOUVER ISLAND, CENTRAL B.C.

OBJECTIVES To aid geological field mapping and mineral exploration in British Columbia by undertaking aeromagnetic surveys and producing data sets to complement existing coverage.

ACHIEVEMENTS MDA funding complemented Geological Survey of Canada funding to conduct aeromagnetic surveys at constant elevation in three areas of British Columbia. Fixed-wing aircraft and inboard systems were primarily used for the task. Flight path recovery and navigation were carried out using a combination of visual (photographic) and electronic systems such as Loran 'C', doppler, inertial guidance and, in central British Columbia, the Global Positioning System. Use of these systems resulted in high precision surveys with a positional accuracy estimated to be approximately 50 metres in most areas.

The results of these surveys were released in both map and digital format. For the Strait of Georgia (NTS 92E, F, G, K, L, & M), 52 maps were produced at 1:50 000 scale and six maps at 1:250 000 scale. For the Taseko Lakes area (NTS 92O & P), 12 maps were produced at 1:50 000 scale and 2 maps at 1:250 000 scale. Ten maps at 1:50 000 scale and 2 maps at 1:250 000 scale were produced for the Williams Lake area (NTS 93A, H).

IMPACT In the Queen Charlotte Sound area, magnetic patterns have helped to define the boundary between the Alexander and upper Jurassic Wrangellian terranes. This boundary has economic importance as it contains important source rocks for hydrocarbon reserves. For central Vancouver Island, the data has been used to complement recently collected seismic data, which will better define the deep structure of the crust and upper mantle, as part of the Canadian Lithoprobe program.

The data collected during this project will prove useful for mapping geological units such as mafic volcanics and

intrusions, and contacts between units, and thus will help to define areas of high potential for mineral exploration. Subsequent to the release of these data, the GSC has demonstrated improved geological definition through digital correction of terrain clearance.

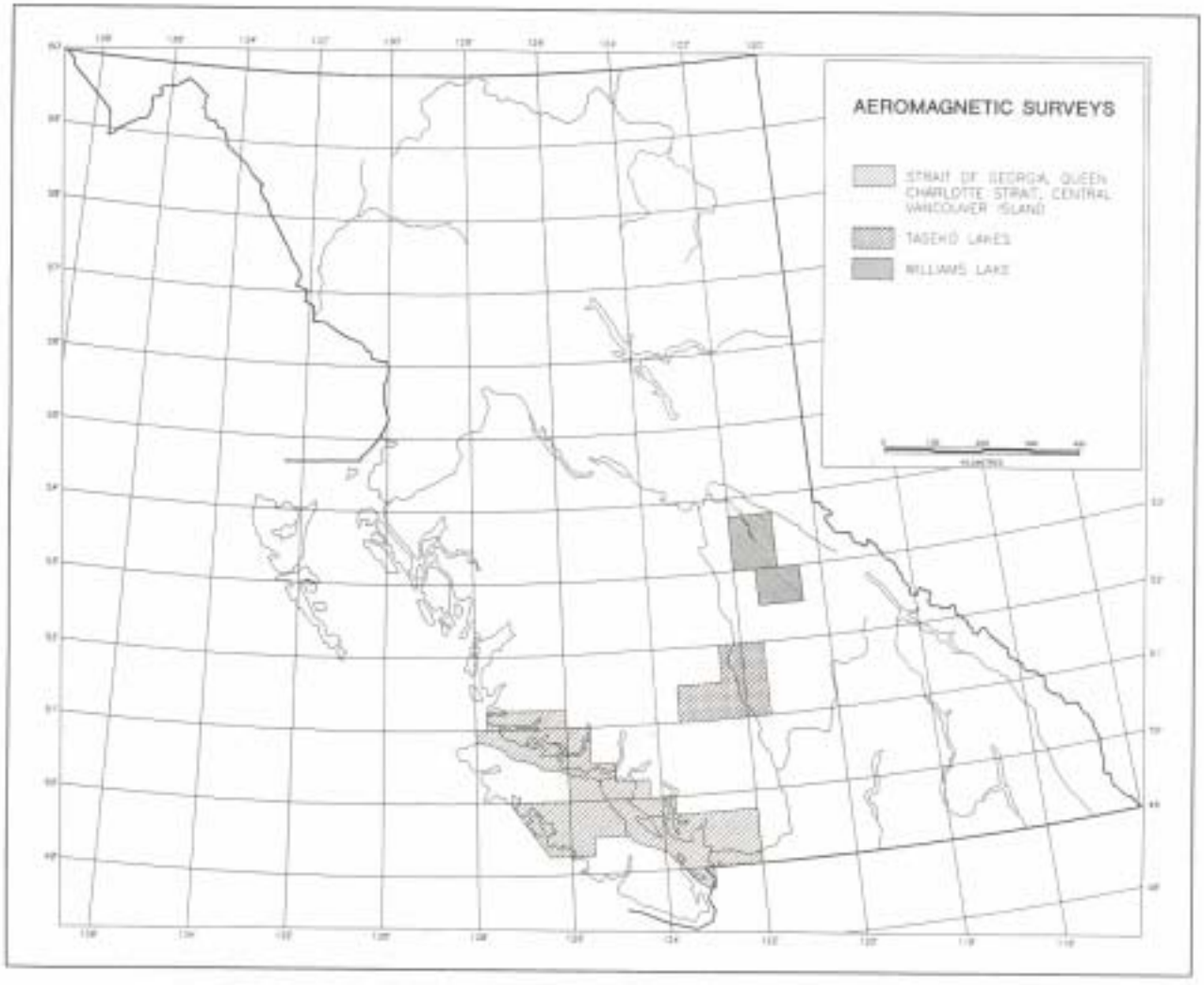
1.2 Geoscience Data Systems

High quality and accessible mineral deposit data are important building blocks for modern exploration. Under this component of the Agreement, MDA funding contributed towards the expansion and redesign of computer files of coal and mineral deposits in order to improve access for industry and government resource managers.

MDA expenditures on the three geoscience data systems projects were $418,000. The majority of funding was directed towards the reinstatement and continued updating of MINFILE, the province's computer inventory of mineral occurrences.

Industry use of MINFILE has increased as a result of this project. By the end of 1991, about 75 percent of the known mineral occurrences in the province will have been investigated and included in MINFILE.

MINFILE data is sold on a commercial basis in hard copy as maps and printouts and in computer format as floppy diskettes for use with MINFILE/pc. MINFILE/pc is a menu-driven search-and-report program for IBM-PC compatible computers. This program is able to efficiently and easily search, sort and manipulate information in the database in response to specific queries and has twelve search screens allowing interrogation of description areas. MINFILE information can be plotted using computer aided drafting systems and integrated with conventional geographic information systems.



Project name	MINFILE
MDA expenditures	$402,028 (1986-1989) $2,747 (Budgeted, 1991)
Principal researcher(s)	L. JONES AND A. WILCOX
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	PROVINCE-WIDE

OBJECTIVES To stimulate increased and more efficient exploration activity by providing accurate and up-to-date information on mineral deposits in the province. This was to be achieved by updating the Ministry of Energy, Mines and Petroleum Resource's computer inventory of provincial mineral occurrences, known as MINFILE.

ACHIEVEMENTS This project provided part of the funding for the reinstatement and continued updating of MINFILE. Under the MDA, the system was upgraded to contain 18 more field elements. As well, existing geological data were enhanced.

By the end of 1991, about 75 percent of the known mineral occurrences in the province will have been investigated and included in MINFILE. Of this, approximately 58 percent have been or will be released to the public at a 1:250 000 scale for use with MINFILE/pc.

Under the MINFILE project, a magnesite and silica Open File were published and a uranium and thorium Open File were prepared for release.

IMPACT MINFILE has helped to provide solutions to mineral exploration, land-use and mineral resource management problems. Industry use of MINFILE has increased as a result of this project. Over 300 clients are now accessing the system and both the number of MINFILE sales and enquiries are up dramatically. The list of interested clients now includes representatives from 9 provinces, 9 U.S. states, New Zealand, England, Switzerland, China and several African countries. It is anticipated that increased circulation of geoscience data pertaining to British Columbia will serve to attract investment dollars to the province in the years ahead.

MINFILE will ultimately be used as an underlying database for Geographical Information Systems and Expert System technology.

OUTPUTS

Fieldwork Articles

Wilcox, A.F. and Borsholm, C. (1985): MINFILE, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Field work 1985, Paper 1986-1, pages 231-233.

Wilcox, A.F. and Borsholm, C.B. (1986): MINFILE-Redesign and Progress Report, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Field work 1986, Paper 1987-1, pages 433-439.

Wilcox, A.F. (1987): New MINFILE - A Mainframe and Personal Computer Based Mineral Inventory Database, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Field work 1987, Paper 1988-1, pages 549-554.

Jones, L.D. (1988): The Search-and-Report Power of MINFILE/pc, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Field work 1988, pages 613-618.

Open Files

Rublee, V.J. (1986): Platinum Group Occurrences in British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1986-7.

Grant, B. (1987): Magnesite, Brucite and Hydromagnesite Occurrences in British Columbia (report, with map in pocket), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1987-13.

Foye, G. (1987): Silica Occurrences in British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1987-15.

Jones, L.D. (1990): Uranium and Thorium Occurrences in British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1990-32.

MINFILE Releases

48 MINFILE areas released since 1986.

Talks and Displays

Presentations were made at the following:

- Annual Cordilleran Roundup in Vancouver, British Columbia, 1986-1990.

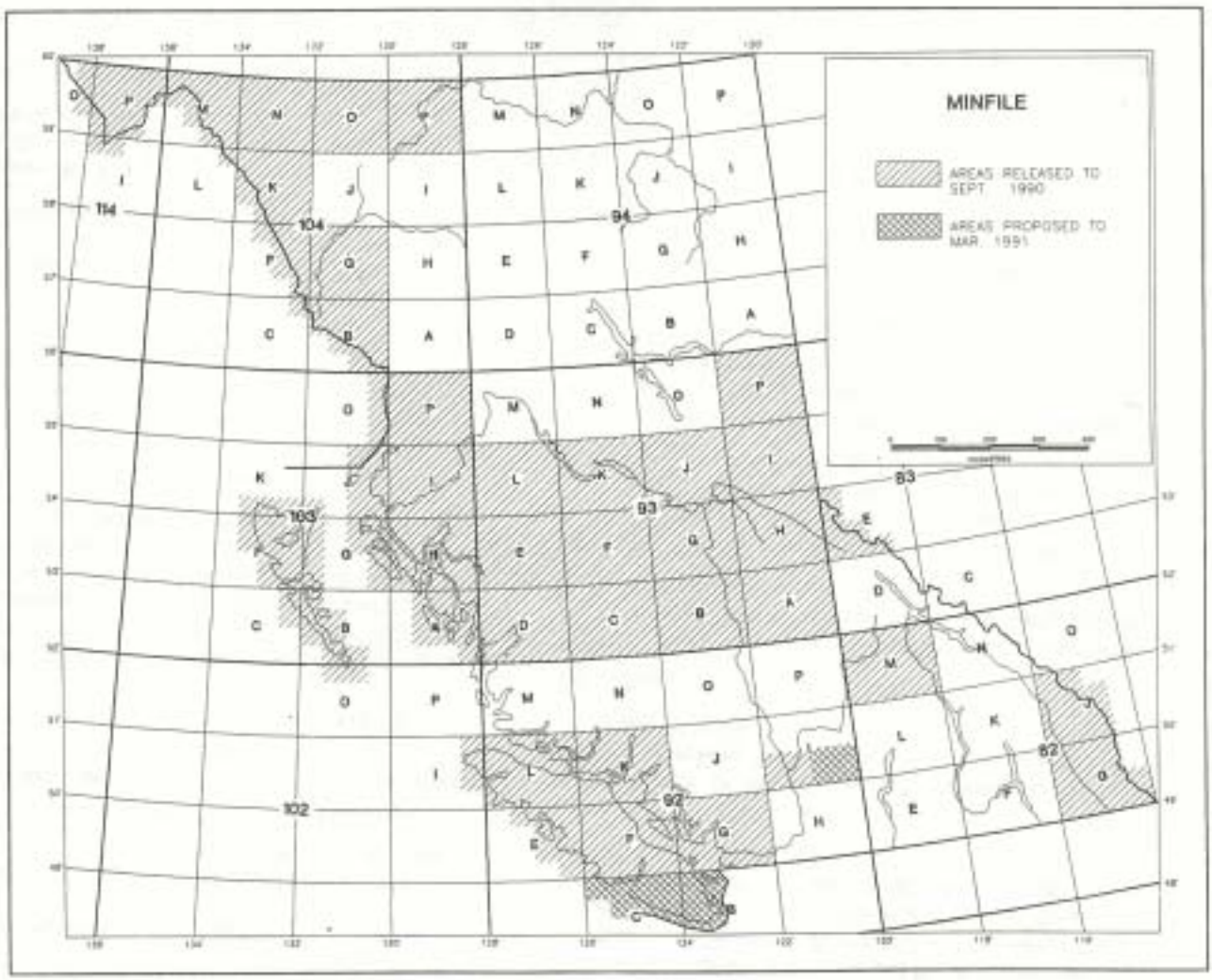
MINFILE, the province's computer inventory of mineral occurrences, is widely available in hard copy as maps and printouts and in computer format as floppy diskettes.

- Annual Meeting of the Vancouver Branch of the Computer Oriented Geological Society in Vancouver, British Columbia, 1988.
- Exploration Group Meeting in Kamloops, British Columbia, 1989.
- Kootenay Exploration and Mining Conference in Nelson, British Columbia, 1989.
- Meeting of industry users in Campbell River, British Columbia, 1989.
- Meeting of industry users in Nanaimo, British Columbia, 1990.
- GeoInfo IV Conference in Ottawa, Ontario, 1990.

Project name	COMPUTER FILE – RADIO METRIC AGE DATES
MDA expenditures	$3,625 (1986)
Principal researcher(s)	A. BENTZEN
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	VANCOUVER

OBJECTIVES To provide support to the exploration industry by compiling a computer database file of radiometric dates for British Columbia.

ACHIEVEMENTS Approximately 3,000 radiometric dates from British Columbia geological sites were entered into a computer to produce a master database accessible by modem/diskette/and 9 track tape. The British Columbia Ministry of Energy, Mines and Petroleum Resources received a master copy of the database on diskette and computer tape as well as updates of all dates added later.



IMPACT Geologists in government and industry have been provided with access to this valuable database which has proved of assistance in mapping and exploration.

OUTPUTS

Fieldwork Articles

Bentzen, A. (1986): Report on the Establishment of a Computer File of Radiometric Dates; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 441-442.

Project name	LITHCHEM
MDA expenditures	$9,600 (1987)
Principal researcher(s)	A. SINCLAIR
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH AND THE UNIVERSITY OF BRITISH COLUMBIA
Project location	UBC

OBJECTIVES To assist the exploration industry by constructing a rapid evaluation (computer-based) system for whole rock chemical analyses of volcanic rocks in British Columbia. The project intended to produce a system that would be of use both for theoretical and applied studies.

ACHIEVEMENTS A software system was developed to permit data entry, data selection and data display with a variety of two-dimensional graphs to assist recognizing magmatic trends and superimposed alterations. An extensive file of more than 2200 chemical analyses of volcanic rocks from the Canadian Cordillera was input and integrated with supplementary geological information on age and classification.

IMPACT This project has produced a chemical database for mesozoic volcanic rocks. Although the information has not been well publicized, it has been well received by those aware of it.

OUTPUTS

Fieldwork Articles

Harrop, J.C. and Sinclair, A.J. (1985): LITHCHEM: An integrated geological database for microcomputers, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1985, Paper 1986-1, pages 285-289.

De Rosen-Spence, A. and Sinclair, A.J. (1986): Classification of the Cretaceous Volcanic Sequences of British Columbia and Yukon, The University of British Columbia and the *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1986, Paper 1987-1, pages 419-427.

De Rosen-Spence, A. and Sinclair, A.J. (1987): Lower Jurassic volcanism of the Stikine superterrane, The University of British Columbia and the *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, pages 211-216.

Radlowski, Z. and Sinclair, A.J. (1989): LITHCHEM - Geological Database System: Recent Developments, The University of British Columbia and the *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1990-1, pages 619-620.

1.3 Market, Technical and Feasibility Studies

Under this component, studies were carried out to assess British Columbia's future mineral supply, collect and analyze mineral economic data, identify market potential for selected industrial mineral commodities and examine the feasibility of introducing new techniques and technologies in mineral development. In 1988, a new program was added, which funded research into industry-wide problems, such as acid mine drainage.

Many of the projects were initiated by industry and carried out on a cost-shared basis.

Project outputs that are currently publicly available are marked with an ** and are listed in Appendix B. Most cost-shared project reports will become available in the future as limited periods of confidentiality expire.

Activities were divided into four sub-components: Mineral Economic Data Development, Mineral Opportunities, Mineral Supply Forecasting and Research and Development.

MINERAL ECONOMIC DATA DEVELOPMENT

MDA expenditures under the Mineral Economic Data Development sub-component were approximately $128,000. Seven projects were supported which provided industry and government with new mineral economic data to support policy work and decision making. The majority of funding was directed towards the design and implementation of a computer database of mineral sector data, the Mine Profile System. Other studies looked at the relative tax burden imposed on new mine developments in jurisdictions across Canada, the impact of upcoming mine closures on local communities, public attitudes towards the mining industry, native participation in mining, the development of mine-specific reclamation funds and the feasibility of establishing a custom processing facility for industrial minerals.

MINERAL OPPORTUNITIES

The two types of studies funded under the Mineral Opportunities sub-component were mineral market and technology development projects. Total MDA expenditures were about $555,000.

The purpose of the mineral market studies sub-component was to demonstrate the export market potential and import replacement opportunities for provincial industrial minerals. British Columbia currently imports a significant amount of raw and semi-manufactured products made from minerals for which the province has an abundant resource potential. Development of these resources would not only strengthen the provincial mineral sector, but also create manufacturing opportunities. Furthermore, the development of these resources would reduce the province's reliance on imported materials and provide opportunities for increased mineral commodity exports.

Seven studies to examine the market potential for selected provincial mineral commodities were funded. Local processing and export opportunities for jade, gypsum, feldspar, talc, dimension stone, barium carbonate and garnet were analyzed. Another study assessed the costs involved in transporting industrial minerals to market. The results of these studies have proved very useful to industry and several of the commodities studied are currently being evaluated by the private sector for development.

The technology studies were designed to ensure that the province's mining industry would be able to benefit from changing economic conditions and technologies by developing and adopting relevant technologies. This was to be achieved by providing "seed money" to stimulate research, development and demonstration work in the province by private industry in the fields of mineral exploration technology, mineral processing and recovery, coal fuel product development and utilization and mine reclamation and environmental problems. The aim was to provide incentives to companies to expand their research capabilities and to provide a focus for applied minerals and mining research.

Of the nineteen technology studies carried out, two studies addressed the issue of worker safety. Nine other studies looked at the feasibility of introducing new techniques and technologies into mineral development. Several of the applications studied have already been implemented by industry to enhance resource recovery.

Four projects addressed the environmental problems associated with mining and in particular for the prevention, treatment, monitoring and control of acid mine drainage. These projects have contributed towards a greater understanding of the issues and have worked to develop solutions.

MINERAL SUPPLY FORECASTING

MDA funding of $38,500 contributed towards the purchase of world metal market reports from the Commodity Research Unit of London, England. These reports have provided essential market intelligence information for policy analysis and planning.

RESEARCH AND DEVELOPMENT

Beginning in 1988, acid mine drainage research became a priority under the MDA. Most of the studies funded under the research and development sub-component were concerned with acid mine drainage research.

Total MDA expenditures on this sub-component were approximately $480,000. About half of the projects were cost-shared with industry and total project costs were often

several times greater than the MDA contribution. The projects funded entirely by the MDA were of a more generic nature. The information produced had broad applications which was relevant to both industry and regulatory agencies.

All acid mine drainage projects were recommended and approved by the British Columbia Acid Mine Drainage Task Force. The Task Force is composed of representatives of mining companies, universities, the Mining Association of British Columbia and several federal and provincial government agencies. It is recognized as a world leader in acid mine drainage research and is currently building domestic experise that is sought after world wide.

The achievements of the acid mine drainage research projects have been considerable. Awareness of the issue has been heightened, the best understanding of acid mine drainage available has been collected together in a technical guide and published, alternative waste disposal and treatment methods have been evaluated and a computer program to predict the potential for acid generation has been developed. Acid mine drainage research is a relatively new science and the outcomes of the MDA projects will provide valuable information for future studies.

1.3.1 Mineral Economic Data Development

Project name	MINE PROFILE SYSTEM
MDA expenditures	$72,752 (1986-1988)
Principal researcher(s)	CONSOLIDATED COMPUTER MANAGEMENT INCORPORATED
Supervising agency	B.C. MINERAL POLICY BRANCH
Project location	VICTORIA

OBJECTIVES To design and implement a computer database of British Columbia mineral sector data in order to support government policy work and data dissemination.

ACHIEVEMENTS A consultant was hired to design an interactive database composed of several modules. Appropriate hardware was selected and purchased. Data on geology, reserves, grades, mine plans, capital and operating costs, ownership, personnel, contracts, labour unions, for all current mines in the province were compiled and input. Significant numbers of historical producers were researched and entered in the system, as well as selected potential producers. Although the mine module and company module are the most complete, there is also a commodity module which contains information on contracts.

IMPACT The project produced an in-house database of the British Columbia mineral sector that has enhanced government's ability to respond to enquiries and issues affecting the industry. Use to date, however, has been limited due primarily to staffing constraints.

OUTPUTS

A customized computer software system was specially developed for the Mineral Policy Branch of the Ministry of Energy, Mines and Petroleum Resources - the 'Mine Profile System.'

Project name	COMPARATIVE TAX STUDY
MDA expenditures	$2,680 (1986)
Principal researcher(s)	B. W. MACKENZIE
Supervising agency	B.C. MINERAL POLICY BRANCH
Other participating agencies	QUEEN'S UNIVERSITY CENTRE FOR RESOURCE STUDIES
Project location	QUEEN'S UNIVERSITY

OBJECTIVES To assist government in policy development and decision making by analyzing and reporting on the relative tax burdens on new mine developments across Canada and evaluating the effects of changes in non-profit taxes introduced in the 1985 British Columbia provincial budget.

ACHIEVEMENTS This project produced a report that updated a 1985 study on the effects of location on mine development economics among several Canadian regions and provinces. The report demonstrated the improved tax climate that resulted from changes introduced in the 1985 British Columbia budget, but also noted that the costs of developing and operating a mine in British Columbia (mainly attributable to higher wage rates and the effect of more difficult topographic conditions on infrastructure costs) were relatively high compared to other provinces.

IMPACT Information was provided to government policy makers on relative tax environments across the country. British Columbia's higher costs were emphasized and the province's attempts to improve the taxation of the mineral sector were demonstrated. This study was one of the many inputs used in designing the Mineral Tax Act which took effect on January 1, 1990.

OUTPUTS

Mackenzie, B.W., Davis, D.W. and Bilodeau, M.L. (1986): *Locational Aspects of Mine Development Economics: Effects of the 1985 British Columbia Budget.* Queen's University Centre for Resource Studies, February, 1986.

Project name	STRUCTURAL CHANGE IN THE MINING INDUSTRY
MDA expenditures	$10,000 (1989)
Total project cost	>$20,000
Principal researcher(s)	WESTERN ECONOMIC CONSULTING LIMITED AND CLAYTON RESOURCES LIMITED
Supervising agency	B.C. MINERAL POLICY BRANCH
Project location	VICTORIA

OBJECTIVES To collect information and forecast the impact of possible mine closures in British Columbia over the next 10 years. This project intended to assess the likely impacts of these mine closures on affected workers and communities and to review existing government programs to guide government policy and decision-making.

ACHIEVEMENTS A study was produced which identified expected mine closures in British Columbia and assessed the extent to which a mine closure might give rise to community adjustment problems. Using Ministry data, possible mine closures over the next 10 years were forecast and an analysis of the degree of community dependence on the mine was presented. Existing government programs were reviewed. Where a gap was identified between the nature of the adjustment problems and the available assistance programs, recommendations were made for changes to those programs or for new initiatives.

IMPACT This study provided valuable input into the Inter-Ministerial Mine Closure Task Force, which was formed to develop a broad strategy of government action to maintain employment and incomes in the face of anticipated closures or reduced operations at mines in British Columbia. Many of the report's recommendations were adopted by the Task Force.

Mining is the economic mainstay of many communities throughout B.C.

OUTPUTS

Western Economic Consulting Limited and Clayton Resources Limited (1989): *The Impact of Mine Closure in British Columbia*. A report prepared for the Province of British Columbia Mine Closure Task Force chaired by the Ministry of Energy, Mines and Petroleum Resources, 1989.

Project name	PUBLIC ATTITUDE SURVEY
MDA expenditures	$10,000 (1989)
Total project cost	>$20,000
Principal researcher(s)	MARKTREND MARKETING RESEARCH INC.
Supervising agency	MINING ASSOCIATION OF BRITISH COLUMBIA
Other participating agencies	B.C. MINERAL POLICY BRANCH
Project location	PROVINCE-WIDE

OBJECTIVES To survey public attitudes in British Columbia towards the mining industry, in order to obtain and report on information that would assist government and industry in the development of appropriate strategies for an improved public image.

ACHIEVEMENTS A report was produced which documented the results of the public opinion survey. A total of 663 telephone interviews were conducted with residents throughout the province. Questions focused on the following: 1. Determining the level of public understanding and appreciation of the economic impact of mining; 2. Identifying concerns surrounding mining that are most important to British Columbians; 3. Ascertaining the level of public understanding on land use issues affecting the mining industry, and what attitudes are held by the public; and 4. Determining how these findings differ among various segments of the population. Recommendations on future communication strategies for the Mining Association were also provided.

IMPACT This project led to the development of an expanded communications program by the Mining Association of British Columbia with a view to educating the general public on the economic impact of the mining industry in British Columbia. In particular, the Association concentrated on communication strategies which emphasized the environmental impacts of mining, the Mine Development Review Process, careers in mining and safety in the mining industry. Communications with communities throughout the province were also opened up.

Also, the Ministry of Energy, Mines and Petroleum Resources used the results of this study as input into decision making regarding their communications strategy.

OUTPUTS

Marktrend Marketing Research Incorporated (1989): *Attitudes to Mining in British Columbia.* A Summary Report presented to the Mining Association of British Columbia, 1989.

Marktrend Marketing Research Incorporated (1989): Presentation of *Attitudes to Mining in British Columbia* to a Joint Meeting of the Mining Association of British Columbia and British Columbia and Yukon Chamber of Mines Luncheon Meeting, 1989.

Project name	INDUSTRIAL MINERALS CUSTOM MILLING
MDA expenditures	$5,000 (1989)
Principal researcher(s)	AINSWORTH-JENKINS HOLDINGS INC.
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	VANCOUVER AND EUROPE

OBJECTIVES To supply government and industry with a preliminary evaluation of the opportunities available and the feasibility of establishing a custom processing facility for industrial minerals in British Columbia.

ACHIEVEMENTS A report was prepared which describes the history and economics of three successful custom processing plants that were visited in Europe. Based on the experiences of these operations, the limitations and potential for custom processing in a British Columbia location are described. Recommendations are also made as to the types of minerals/products that may be economically viable and the markets that are potentially accessible to British Columbia producers. Factors cited that make British Columbia an attractive location for a industrial mineral custom processing facility are: its wealth of industrial minerals, its reputation as a reliable and competent trading partner, and its proximity to Pacific Rim nations. The report suggests that British Columbia could export processed materials in empty container ships returning to industrialized Pacific Rim countries. The possibility of joint ventures with European or American custom processors is also discussed.

IMPACT Industry interest in the report has been high, with approximately 30 copies sold between May 1989 and January 1990.

OUTPUTS

Ainsworth-Jenkins Holdings Incorporated (1989): *The Custom Milling of Industrial Minerals in British Columbia: A Study of Commercial Feasibility.*** Study funded by the Canada - British Columbia Mineral Development Agreement. March 1989.

Project name	NATIVE PARTICIPATION IN MINING
MDA expenditures	$8,125 (1990)
Total project cost	>$16,000
Principal researcher(s)	B. JANKE
Supervising agency	B.C. MINERAL POLICY BRANCH
Project location	VICTORIA

OBJECTIVES To coordinate and prepare an interprovincial report on native participation in the mining industry. This project intended to provide government with information that would help future decisions regarding native participation in existing and developing mining operations.

ACHIEVEMENTS A report was produced which examined the issue of native participation in the Canadian mining industry. The following information was presented: a collection of "best" case studies; a listing of government programs/policies that natives and/or companies could access to increase native participation; a demographic profile of the native community; Statistics Canada and Census Canada data; and an annotated bibliography.

IMPACT The project produced a comprehensive source of information on native involvement in mining which will be helpful to governments in British Columbia and other jurisdictions when deciding on proposed mine developments and potential community impacts.

OUTPUTS

Sub-Committee of the Intergovernmental Working Group on the Mineral Industry (1990): *Phase I Report on Native Participation in Mining.*

Project name	B.C. RECLAMATION FUND STUDY
MDA expenditures	$19,500 (1990)
Total project cost	>$39,000
Principal researcher(s)	ACTREX PARTNERS LIMITED
Supervising agency	B.C. MINERAL POLICY BRANCH
Other participating agencies	EQUITY SILVER MINES LIMITED
Project location	VANCOUVER

OBJECTIVES To develop an investment policy for mine-specific reclamation funds that will generate fund income sufficient to finance required post-closure mine reclamation for as long as necessary. Recent changes to the Mines Act made provision for the establishment of such funds as a condition of operation for mines with significant long term reclamation requirements and no other source of reclamation funding.

ACHIEVEMENTS The nature of mine reclamation was reviewed, with particular emphasis on the Equity Silver Mine in west-central British Columbia. Current and expected future conditions in financial markets were also assessed. A general framework for the problem was developed and a report was produced which presented recommendations for an Investment Policy for mine reclamation. Computer software, to analyze the impacts and risks of Fund deficiencies to the Province, was also developed.

IMPACT This report will provide input into a new form of reclamation security, called a mine-specific reclamation fund, that is supported by both industry and government.

OUTPUTS

Actrex Partners Limited (1990): *Report of the Establishment of an Investment Policy for the Reclamation Fund at Equity Silver Mine.*

1.3.2 Mineral Opportunity Market Studies

Project name	MOHAWK JADE TILE PRODUCTION STUDY
MDA expenditures	$25,000 (1987)
Total project cost	>$50,000
Principal researcher(s)	M. WALDER AND E. PLANK
Supervising agency	B. C. GEOLOGICAL SURVEY BRANCH
Other participating agencies	MOHAWK OIL COMPANY LIMITED
Project location	PROVINCE-WIDE

OBJECTIVES To promote local processing of British Columbia's jade resources by examining and reporting on the feasibility of constructing a local facility to process subgem quality jade into decorative tiles.

ACHIEVEMENTS A study was done of current stone cutting technology and its potential application to jade, given jade's unique toughness and texture characteristics. Pilot scale tests were made by selected equipment manufacturers and based on these tests, equipment was selected and flowsheets developed. Capital and operating costs were calculated to determine the cost of the final product and to ensure an adequate projected rate of return. A site selection survey identified the southwest mainland of the province as the optimal location for the processing facility.

IMPACT Due to difficulties in securing marketing arrangements, progress in developing a jade tile processing facility has not gone beyond the conceptual stage.

OUTPUT

Waldner, M. and Plank, E. (1986): *Jade Tile Feasibility Study*. November 1986.

Project name	INDUSTRIAL MINERALS MARKET STUDIES
MDA expenditures	$4,039 (1987)
Principal researcher(s)	B. AINSWORTH
Supervising agency	B.C. MINERAL POLICY AND GEOLOGICAL SURVEY BRANCHES
Project location	PROVINCE-WIDE

OBJECTIVES To promote the development of British Columbia's industrial minerals by developing a conceptual design for a series of market studies of British Columbia's industrial minerals. Those with good growth prospects, but for which marketing information was con-

sidered to be a constraint to development were to be priorized. The information from this project was intended to assist Ministry staff and the Industrial Minerals Advisory Group in developing future industrial minerals studies.

ACHIEVEMENTS A report was prepared that ranked British Columbia's industrial minerals in order of priority for market studies and developed a design for the Industrial Minerals Market Studies Series. It was suggested that each future study include the following information: a geological description of the mineral; a general overview of end-uses and further processing of the mineral; a map or description of known deposits or occurrences within British Columbia; a review of relevant historical producers; a description of present producers and consumers; and an analysis of potential producers and consumers.

IMPACT The outline has helped Ministry staff and the Industrial Minerals Advisory Group develop guidelines for further industrial mineral studies.

OUTPUTS

Ainsworth, B. (1987): *Industrial Minerals Marketing Studies Project: Conceptual Design for the Study Series*. An internal report prepared for the Ministry of Energy, Mines and Petroleum Resources.

A presentation was made in Vancouver, British Columbia, to the Industrial Mineral Advisory Group in 1986.

Project name	GYPSUM MARKET STUDY
MDA expenditures	$15,000 (1987)
Total project cost	>$30,000
Principal researcher(s)	KING, MURPHY, LAVALIN CONSULTANTS
Supervising agency	B.C. GEOLOGICAL SURVEY AND MINERAL POLICY BRANCHES
Other participating agencies	QUEENSTAKE RESOURCES LIMITED
Project location	PROVINCE-WIDE

OBJECTIVES To encourage the development of British Columbia gypsum resources by providing information on the eastern Pacific Rim market potential for British Columbia gypsum and developing a marketing scenario. The project also intended to identify gypsum specifications needed for each segment of the market, including prices, production and consumption volumes.

ACHIEVEMENTS A study was carried out in joint cooperation with Queenstake Resources Limited, a publicly-owned Canadian mining company. A detailed description of gypsum and its role in today's industrial world was provided. Marketing opportunities for British Columbia gypsum in the North American "Pacific Northwest" area were outlined. The report suggested the best opportunities for British Columbia's gypsum were in the supply of crude gypsum to the wallboard and cement plants located in the Vancouver port area and in Seattle and Tacoma.

IMPACT Industry interest in the project has been high and over 30 copies of the report have been sold. The output of the study was used in a feasibility assessment of the Haines Gypsum project in northwestern British Columbia.

OUTPUTS

King, Murphy, Lavalin Consultants (1987): *Marketing Study of British Columbia's Gypsum in the Pacific Rim Area of North America.***

Project name	FELDSPAR MARKET STUDY
MDA expenditures	$35,105 (1988-1989)
Principal researcher(s)	MINERAL MARKETING INCORPORATED
Supervising agency	B.C. GEOLOGICAL SURVEY AND MINERAL POLICY BRANCHES
Project location	PROVINCE-WIDE

OBJECTIVES To promote the development of feldspar, nepheline syenite and other feldspathic materials in British Columbia. This goal was to be achieved by evaluating the market potential and identifying the uses and specifications of these minerals in West Coast and Pacific Rim glass and ceramics plant.

ACHIEVEMENTS A report was produced which described the physical characteristics and industrial uses of feldspar, nepheline syenite and other feldspathic materials. Information was provided on world production, supply, international trade and prices. Ten potential production sites in British Columbia were briefly evaluated. It was found that a producer of feldspar or nepheline syenite in British Columbia would enjoy a freight advantage in western markets over eastern producers of both materials and also over southern California or Mexican suppliers of feldspar. Depending of the nature of the deposit, transportation costs and the effectiveness of sales and marketing efforts, the potential market for British Columbia producers was projected to range from 25 000 to 100 000 tonnes annually. The primary markets were identified as glass and ceramics plants in the Western Provinces, the Pacific Northwest, Northern California and Pacific Rim countries.

IMPACT Industry interest in the report was high; it was one of the best selling reports produced under the MDA. As a result of the project, one privately funded follow-up market study was carried out and two feldspar deposits were studied for development. As well, the nepheline syenite deposit at Trident Mountain was staked and evaluated for development.

OUTPUTS

McVey, Hal (1988): *A Study of Markets for British Columbia's Nepheline Syenite and Feldspathic Minerals.*** A report produced by Mineral Marketing Incorporated. March 1988.

Feldspar Resources Report (in preparation).

Presentations were made at the following:

- Annual Meeting of Canadian Institute of Mining and Metallurgy in Edmonton, Alberta, 1988.
- Industrial Minerals Advisory Committee Meeting in Vancouver, British Columbia, 1988.

Project name	MARKET STUDY: MODIFIED TALC
MDA expenditures	$1,518 (1989)
Total project cost	>$3,000
Principal researcher(s)	TEMANEX CONSULTING INCORPORATED
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Other participating agencies	PACIFIC TALC LIMITED
Project location	PROVINCE-WIDE

OBJECTIVES To identify market opportunities and project market sizes for modified talc in British Columbia by analyzing the West Coast papermaking industry and its near term growth potential and assessing papermaking mineral pigments markets and trends.

ACHIEVEMENTS A report was produced that analyzed West Coast mineral pigment market trends with regards to talc's potential and limitations in the papermaking industry. Talc's current usage was found to be limited and primarily for pitch control rather than for paper filling and coating. The major inhibiting factors to greater usage of talc were found to be twofold: in British Columbia kaolin has been traditionally used as a low-cost alternative; and, the hydrophobic nature of talc's surface is such that it results in a high dusting tendency in offset printing, which is the dominant printing process in North America. The report concluded that if the offset dusting problem were solved and talc was competitively priced, it might be possible for talc to capture roughly a 20% share of the West Coast papermaking pigments market over the next five to ten years.

IMPACT The results of this study were very useful to Pacific Talc Limited and have helped the company get one step closer to actual production from their deposit near Boston Bar.

OUTPUTS

Temanex Consulting Incorporated (1988): *North American West Coast Pigment Markets with Emphasis on Talc Prospects.* Under the terms of the agreement with Pacific Talc Limited, the report will remain confidential until 1991.

Project name	DIMENSION STONE MARKET STUDY
MDA expenditures	$15,143 (1989)
Principal researcher(s)	J. PAGE/BEATY GEOLOGICAL SERVICES
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	PROVINCE-WIDE

OBJECTIVES To diversify the province's mineral industry by identifying market opportunities for British Columbia dimension stone which would lead to import replacement and new export opportunities.

ACHIEVEMENTS A market study was undertaken which identified opportunities for British Columbia dimension stone. Premium quality colored granites were found to provide the best market opportunities. Fabricated grey colored granites also appeared to have good market potential. Competitiveness was cited as the most important factor to developing a British Columbia dimension stone industry.

MDA studies advanced local processing and export opportunities for jade, gypsum, feldspar, talc, dimension stone, barium carbonate and garnet.

IMPACT This project and the dimension stone assessment project have generated considerable industry interest. Numerous requests for information have been received by the Ministry of Energy, Mines and Petroleum Resources. Plans are currently underway to develop two new quarries and three quarries have started production since these projects were originally undertaken. A mapping project to identify potential exploration targets has been proposed and will be undertaken in 1990.

OUTPUTS

Page, J. W. (1989): *British Columbia Dimension Stone Market Study.*** March 1989.

A presentation of the report was made to the Industrial Minerals Advisory Committee in the spring of 1989.

Project name	BARIUM CARBONATE MARKET STUDY
MDA expenditures	$10,000 (1990)
Total project cost	>$20,000
Principal researcher(s)	PRODUCTIVE CONSULTANTS COMPANY
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	PROVINCE-WIDE

OBJECTIVES To identify North American market conditions for barium products and the economic outlook for the barium chemical manufacturing facility proposed by Mountain Minerals Company Limited.

ACHIEVEMENTS A report was produced that identified the following: the size of the North American market, supply and demand patterns, economics, major barium chemical uses, market growth potential, competitive forces and Mountain Minerals Company Limited's distinct advantages. A list of industrial consumers was supplied in the Appendix. The report concluded that the marketing climate was very favourable and recommended that Mountain Minerals proceed with the barium chemicals project.

IMPACT This study is being used by Mountain Minerals Company Limited to assess whether or not the company will enter the barium carbonate production business.

OUTPUTS

Productive Consultants Company (1990): *The North American Barium Chemical Market*. Under the terms of the agreement this report will remain confidential until 1992.

Project name	GARNET MARKET STUDY
MDA expenditures	$11,195 (1990)
Total project cost	>$22,000
Principal researcher(s)	HEBB RESOURCES INTERNATIONAL INCORPORATED
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Other participating agencies	POLESTAR EXPLORATION INCORPORATED
Project location	PROVINCE-WIDE

OBJECTIVES To promote the development of high-quality British Columbia garnet by analyzing supply and demand factors, market trends, product specifications, new uses, and by forecasting a strategy for penetrating existing or anticipated markets.

ACHIEVEMENTS A report was prepared that described current world-wide sources and industrial demand for garnet. The most promising market for garnet was found to be as an abrasive blast cleaner. Garnet's ability to win market share to date was seen as limited by two factors: relatively high price and limited availability. A strategy for British Columbia garnet producers to penetrate these markets was identified. Both demand and price outlook for British Columbia garnet products was regarded as very positive.

IMPACT This study is being used by Polestar Exploration Incorporated to help assess whether or not the company will develop a garnet-bearing skarn deposit at Crystal Peak, in the Hedley area of British Columbia, for abrasive garnet production.

OUTPUTS

Hebb Resources International Incorporated (1990): *Market Study for British Columbia Garnet*. Under the terms of the agreement with Polestar Exploration Incorporated this report will remain confidential until 1991.

Project name	STRATEGIC PLAN, INDUSTRIAL MINERALS
MDA expenditures	$9,222 (1990)
Principal researcher(s)	H. MCVEY
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Project location	PROVINCE-WIDE

OBJECTIVES To stimulate the development of industrial minerals in British Columbia by producing a five- to ten-year strategic plan of geological, process development,

marketing and promotional programs that would be used as the basis for an industrial mineral program under a renewed Economic and Regional Development Agreement.

ACHIEVEMENTS A report was prepared that examined anticipated trends in consumption and production of industrial minerals and assessed British Columbia's advantages and disadvantages with respect to future development. The potential for growth and importance of industrial minerals was emphasized. The structure and activities of the Industrial Minerals Subsection of the British Columbia Ministry of Energy, Mines and Petroleum Resources were analyzed and compared with those of competing jurisdictions in the Pacific Northwest. Recommendations were made regard-ing a five- to ten-year strategic plan for an Industrial Minerals Program which would allow British Columbia to maintain its achieved advantages.

IMPACT This report is being used by government policy makers to assist in planning.

OUTPUTS

McVey, H. (1989): *Strategic Plan: Industrial Minerals Subsection.*

Project name	INDUSTRIAL MINERALS TRANSPORTATION STUDY
MDA expenditures	$20,000 (1990)
Principal researcher(s)	TRANSMODE CONSULTANTS INCORPORATED
Supervising agency	B.C. MINERAL POLICY AND GEOLOGICAL SURVEY BRANCHES
Project location	PROVINCE-WIDE

OBJECTIVES To promote the development of industrial minerals in British Columbia by producing estimates of the costs of transporting industrial minerals to selected markets in North America and overseas countries. The intent of this project was to provide policy makers and potential producers with a "pre-feasibility" assessment of development potential.

ACHIEVEMENTS Frequently the cost of transporting an industrial commodity to market exceeds the cost of mining and processing. Thus, the transporation cost is a critical factor in evaluating the economics of an industrial mineral deposit. This project produced a report that analyzed the cost of transporting 12 industrial minerals from 19 deposit or production sites in British Columbia to potential markets. Nearly 80 different transportation routes were considered in the analysis, each linking a mineral deposit with a potential market in North America or in Pacific Rim countries. The study concluded that for most of the selected sites and markets, the favourable or only possible mode of transportation was by truck. Opportunities to recoup some of the transportation costs by taking advantage of backhaul rates were found to depend on location within the province and the standard of service required. Highway load restrictions in the U.S. were cited as a factor that increased the cost of trucking to U.S. markets. The cost advantages of shipping large volumes of bulk product versus small volumes of palletized or containerized product were determined to be significant.

IMPACT The report was released in August, 1990. While industry has not had time to act on the report, it has been used by the British Columbia Ministry of Regional and Economic Development

OUTPUTS

Transmode Consultants Incorporated (1990): *Transportation Costs for Industrial Minerals Produced in British Columbia.***

1.3.3 Mineral Opportunities Technology Development

Project name	MINE DUMP RESLOPING
MDA expenditures	$18,000 (1986)
Total project cost	>$36,000
Principal researcher(s)	NORECOL ENVIRONMENTAL CONSULTANTS LIMITED, THURBER CONSULTANTS LIMITED, POLSTER ENVIRONMENTAL SERVICES AND WRIGHT ENGINEERS
Supervising agency	B.C. ENGINEERING & INSPECTION BRANCH
Other participating agencies	FORDING COAL LIMITED, WESTAR MINING LIMITED, MINING ASSOCIATION OF B.C. AND B.C. MINISTRY OF THE ENVIRONMENT
Project location	PROVINCE-WIDE

OBJECTIVES To help industry develop new methodology by examining current mine-waste dump management practices and problems. The project's aim was to develop criteria for the management of existing and future mine waste rock dumps in British Columbia, with a particular emphasis on dump face resloping.

ACHIEVEMENTS The project team conducted an extensive literature review to determine the state of the art of mine-waste dump reclamation techniques to meet safety,

stability, end-use productivity and drainage requirements. Questionnaires were completed by 15 mining companies to supplement the literature review, followed by interviews. The data were analyzed to identify the advantages and disadvantages, including costs, of different dump management strategies. The major criteria for costs and end land use objectives were identified and suggestions were made on how these criteria should be weighted. The findings were summarized in a report.

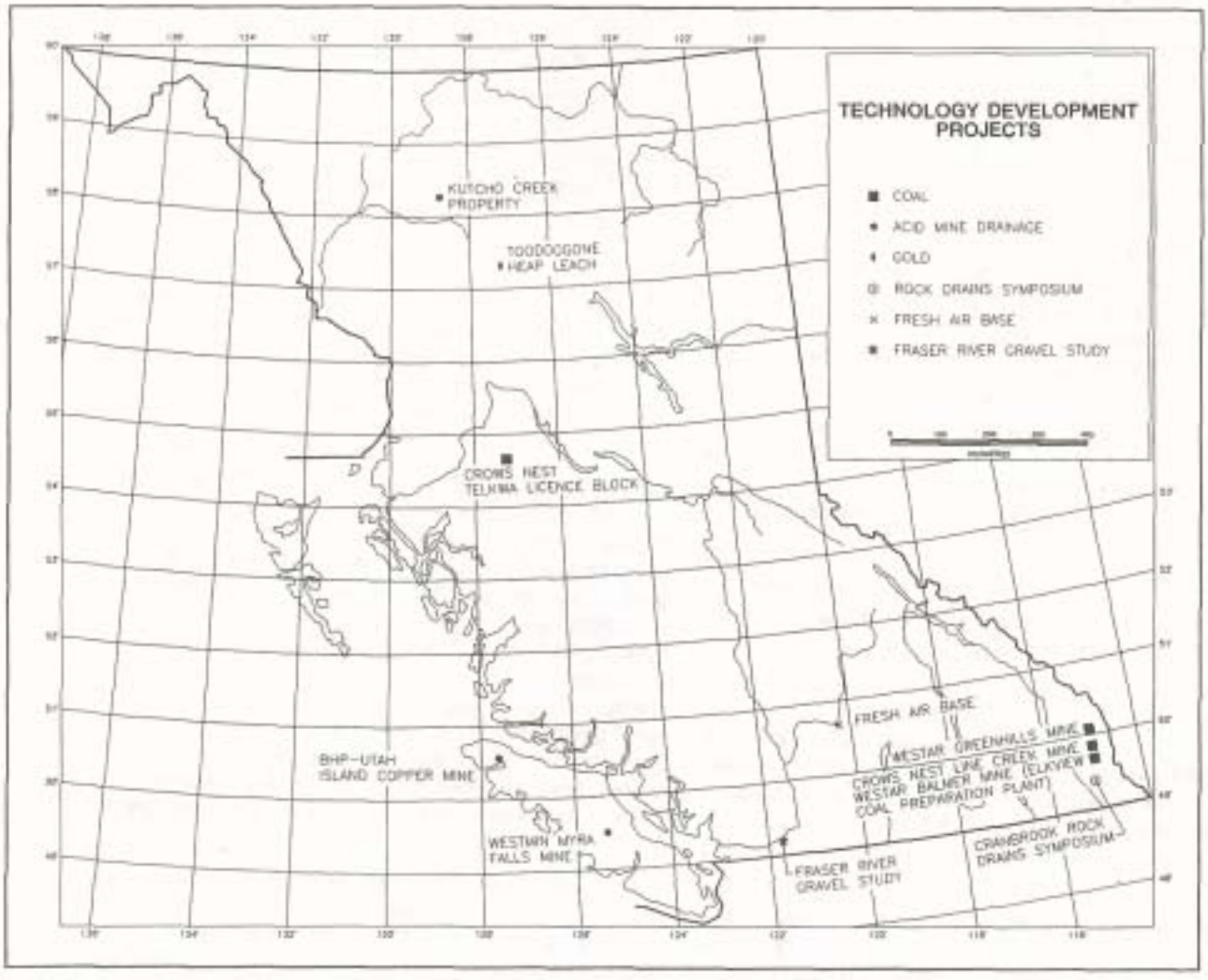
IMPACT The project highlighted issues related to mine waste dump resloping. It facilitated communication and cooperation between the industry and regulatory agencies and pointed out areas requiring further study. The project report has been an important reference for government policies related to resloping.

OUTPUTS

Norecol Environmental Consultants Limited, Thurber Consultants Limited, Polster Environmental Services and Wright Engineers (1986): *Mine Waste Dump Management (Resloping) Study*. 1986.

Project name	**PORTABLE MODULAR MILLS**
MDA expenditures	**$19,935 (1986)**
Total project cost	**>$40,000**
Principal researcher(s)	**TRM ENGINEERING LIMITED**
Supervising agency	**B.C. GEOLOGICAL SURVEY BRANCH**
Other participating agencies	**TRADER RESOURCE CORPORATION AND FLEET DEVELOPMENT**
Project location	**PROVINCE-WIDE**

OBJECTIVES To promote the development of new technology in British Columbia's mineral industry by examining the feasibility of constructing portable concentrating facilities. The project had two components. The first involved identifying prospects in coastal areas of the prov-



ince with known or inferred precious metal reserves that might be made economic by the availability of a portable concentrating facility. The second was the design of a cost-effective modular constructed facility capable of servicing these deposits.

ACHIEVEMENTS A resource assessment was conducted that identified 8 properties with good potential and 36 properties with moderate potential to become economic with the availability of an appropriately-designed portable mill. Several concentrator (mill) designs were developed to handle the specific through-put and metallurgical requirements of these deposits. The designs included both barge-mounted and trailer-mounted modular units that would permit application at either tidewater or inland sites. Capital and operating costs were calculated for three barge-mounted designs and tables were provided for the calculation of costs of trailer-mounted mills based on required components. A report detailing the results of the project was produced.

IMPACT Industry was very interested in the results of the study. Portable modular mills are being considered for at least two of the deposits identified by the resource assessment. Neither deposit, however, has yet reached a production decision.

OUTPUTS

TRM Engineering Limited (1986): *Resource Assessment for Coastal and Western British Columbia and the Development of a Portable Modular Mill Design.*** March 1986.

Project name	HEAP LEACH PRE-FEASIBILITY
MDA expenditures	$3,000 (1987)
Total project cost	>$6,000
Principal researcher(s)	KILBORN ENGINEERING (B.C.) LIMITED
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Other participating agencies	ENERGEX MINERALS LIMITED
Project location	NORTH CENTRAL B.C.

OBJECTIVES To promote new mining technology by investigating the economic viability of heap leaching for operators of numerous potentially leachable gold prospects in the unique climatic conditions in the northern regions of the province. This objective was to be accomplished by examining the feasibility of operating a gold ore heap leach in the Toodoggone area of north central British Columbia.

ACHIEVEMENTS A study was undertaken and a report prepared that examined the economics of operating a 30,000 tonne gold ore heap leach in the Toodoggone area. It was found that at gold prices of (US$) $345 per troy ounce, a positive cash flow would be generated by the treatment of ore grading in excess of 0.21 ounces of gold per ton.

IMPACT This project defined parameters under which seasonal heap leaching of gold ore might be economic in northern regions of the province. The report has been popular with industry, although no northern operations have yet adopted the technology.

OUTPUTS

Kilborn Engineering (B.C.) Limited (1986): *Energex Minerals Limited Toodoggone Project: A Preliminary Evaluation of Heap Leaching.*** July 1986.

Project name	ROCK DRAINS SYMPOSIUM
MDA expenditures	$10,000 (1987)
Total project cost	>$20,000
Principal researcher(s)	B.C. TECHNICAL & RESEARCH COMMITTEE ON RECLAMATION
Supervising agency	B.C. ENGINEERING & INSPECTION BRANCH
Other participating agencies	B.C. MINISTRY OF ENVIRONMENT, MINING ASSOCIATION OF B.C., CROWS NEST BRANCH OF THE CANADIAN INSTITUTE OF MINING AND METALLURGY, BYRON CREEK COLLIERIES, CROWS NEST RESOURCES LIMITED, FORDING COAL LIMITED AND WESTAR MINING LIMITED
Project location	CRANBROOK

OBJECTIVES To provide a forum for both government and industry to discuss state-of-the-art criteria for design and construction of flow-through rock drains in the foundations of overburden dumps. As well, this project intended to provide a record of mine reclamation achievement in British Columbia and provide an up-to-date assessment of current practice.

ACHIEVEMENTS A symposium was organized that reviewed international experience in the design, construction and operation of rock drains to improve their effectiveness and reduce their environmental impacts in British Columbia.

IMPACT All parties to the project were brought up-to-date on the following: location of rock drains, installations, design criteria, monitoring problems and data, costs and cost savings. The information was relevant world-wide.

The MDA sponsored Rock Drain Symposium included a field trip.

Due to the symposium's success, a follow-up session was planned for 1990.

OUTPUTS

British Columbia Technical and Research Committee on Reclamation (1987): *International Symposium on Flow-Through Rock Drains.* Proceedings of the symposium held in Cranbrook in 1986. Bitech Publishers Ltd.**

Project name	VIDEO GRAPHICS DEVELOPMENT
MDA expenditures	$3,000 (1988)
Principal researcher(s)	SPECTRUM GEOLOGICAL SERVICES
Supervising agency	B. C. GEOLOGICAL SURVEY BRANCH
Project location	PROVINCE-WIDE

OBJECTIVES To help industry demonstrate the visual impacts of proposed development scenarios in a readily transportable form by developing techniques to superimpose computer assisted drafting (CAD) graphics on a VHS video image. This project intended to enable industry to present enhanced video presentations to investors, management, regulatory agencies and public.

ACHIEVEMENTS A report and accompanying video were prepared that described how a small company with minimal equipment and expertise could produce a short, inexpensive video presentation incorporating CAD overlays. The overlays could include geological interpretations, geochemical or geophysical anomalies, or proposed mine site developments, all superimposed on a video image of the deposit topography.

IMPACT The report and video have received limited use to date, due in part to technical difficulties. The introduction of new software developments in the future and rapidly decreasing hardware costs may allow for a broader range of applications.

OUTPUTS

A report and video presentation were prepared.

Project name	MINE RESEARCH AND DEVELOPMENT
MDA expenditures	$7,016 (1988)
Total project cost	>$14,000
Principal researcher(s)	BAPTY RESEARCH LIMITED
Supervising agency	B.C. MINERAL POLICY BRANCH
Other participating agencies	MINING ASSOCIATION OF B.C.
Project location	PROVINCE-WIDE

OBJECTIVES To assist industry exploration and development efforts by investigating the state of mining research and development (R&D) in British Columbia.

ACHIEVEMENTS A survey of six mines in the province was undertaken to determine levels of R&D funding. Based on the results of the survey, it was concluded that R&D was underfunded in British Columbia. A report was prepared which documented the results of the survey, identified areas for additional research, and recommended the formation of a central organization to receive and endorse R&D projects, arrange funding and coordinate activities. The report also noted that facilities and expertise available from the University of British Columbia were under-utilized.

IMPACT This project highlighted the need for R&D at mine sites that would increase profits and decrease costs. It was an important factor in the creation of two new positions: the Science/Research Coordinator position at the Mining Association of British Columbia and a Vancouver-based CANMET position.

OUTPUTS

A report was prepared by Bapty Research Limited for use by the Ministry of Energy, Mines and Petroleum Resources and the Mining Association of British Columbia.

Project name	FRESH AIR BASE
MDA expenditures	$10,000 (1988)
Total project cost	>$20,000
Principal researcher(s)	ROCBORE LIMITED
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Other participating agencies	ROCBORE LIMITED/ J.S. REDPATH LIMITED
Project location	KAMLOOPS

OBJECTIVES To improve underground mine safety by providing assistance for the development of a portable, reusable Mobile Safety Base for underground mines.

ACHIEVEMENTS An airtight, reinforced and fire resistant fibreglass shelter was developed to be used as a refuge station in remote areas of mines, in the event of a sudden loss of air quality. This Mobile Safety Base was designed to be linked to the mine's compressed air, water, power and communications systems to provide life support in an emergency. It's compact design allowed it to be portable within most mines. Small dimensions and the ability to nest major components permitted it to be transported by air to remote locations.

IMPACT This project resulted in the manufacture of a portable, re-usable refuge station.

Development of a fresh air base for underground miners was one of the many ways the MDA supported worker safety.

OUTPUTS

Advertisements were placed in the Northern Miner newspaper.

Exhibits were displayed at major national meetings.

Project name	EXTENDED WORK HOURS
MDA expenditures	$4,988 (1990)
Total project cost	>$50,000
Principal researcher(s)	U.S. BUREAU OF MINES, WESTMIN RESOURCES LIMITED, SIMON FRASER UNIVERSITY INSTITUTE FOR HUMAN PERFORMANCE AND CANMET
Supervising agency	B.C. ENGINEERING AND INSPECTION BRANCH
Other participating agencies	U.S. BUREAU OF MINES, WESTMIN RESOURCES LIMITED AND CANMET
Project location	VANCOUVER ISLAND

OBJECTIVES To provide information to the mining industry on the potential safety, fatigue and health effects caused by employees working extended hours at Westmin's Myra Falls underground mining operation on Vancouver Island.

ACHIEVEMENTS A two phase study is being conducted that will monitor workers and working conditions for 24 hours a day over a period of 16 days at Westmin's Myra Falls underground mine. During Phase I, workers were monitored for 8 consecutive days while working 8 hour shifts. A variety of health and safety tests were performed. During Phase II, these same tests will be repeated over 8 consecutive days, after workers have completed 12 hour shifts for a number of months. Comparisons will be made between the 8 hour versus 12 hour shift effects, pre-shift versus post-shift effects and changes over shift period (first day versus last day). A report will be produced which will summarize the results of the study.

IMPACT This study will be used by Westmin Resources, as well as other mining companies and unions, to provide input into decision making regarding the effects of longer shift hours in underground mines.

OUTPUTS

A final report will be produced when the study is complete.

Project name	WESTAR SPIRAL TEST
MDA expenditures	$10,000 (1987)
Total project cost	>$20,000
Principal researcher(s)	CANMET
Supervising agency	B.C. ENGINEERING AND INSPECTION BRANCH
Other participating agencies	CANMET'S COAL RESEARCH LABORATORIES
Project location	SOUTHEAST B.C.

OBJECTIVES To increase productivity in the coal mining industry by assessing the performance of spiral concentrators for the recovery of clean coal from refuse and intermediate products at Westar Mining Limited's Elkview coal preparation plant.

ACHIEVEMENTS CANMET's Coal Research Laboratories at Devon, Alberta were commissioned to undertake a total of 16 tests on 3 samples from the Elkview plant to determine the quality of products, operating variables and separation efficiency. These tests led to the conclusion that the addition of spirals to the Elkview plant would improve the recovery of fine coal and produce refuse with an acceptable high ash content.

IMPACT The project demonstrated that spiral concentrators could be used to upgrade fine coal recovery in a southeastern British Columbia coal preparation plant. Westar subsequently installed spirals at its Balmer plant. Eventually the use of spirals may lead to better utilization of mined coal at other sites, thus increasing the productivity and life of the province's coal mines.

OUTPUTS

Mikhail, M.W., Humeniuk, O.E. and Parsons, I.S. (1986): *Recovery of Coal from Elkview Plant Refuse by Using Spirals*; Energy Research Program Coal Research Laboratories, CANMET, Energy, Mines and Resources Canada, Division Report ERP/CRL 87-137 (CF). Copies available from CANMET.

Project name	COAL WASTE DUMP STABILITY
MDA expenditures	$30,000 (1987)
Total project cost	>$60,000
Principal researcher(s)	GOLDER ASSOCIATES LIMITED
Supervising agency	B.C. ENGINEERING AND INSPECTION BRANCH
Other participating agencies	FEDERAL PANEL ON ENERGY RESEARCH AND DEVELOPMENT, CANMET, BULLMOOSE OPERATING CORPORATION, BYRON CREEK COLLIERIES, CROWS NEST RESOURCES LIMITED, FORDING COAL LIMITED, QUINTETTE COAL LIMITED, WESTAR MINING LIMITED AND MINING ASSOCIATION OF B.C.
Project location	PROVINCE-WIDE

OBJECTIVES To improve industry and government decision-making and planning by providing a better understanding of the factors that affect coal mining waste dump failures. By developing more accurate predictions of the risk of failure, this project intended to contribute towards the creation of more equitable regulation of coal waste dumps and more cost-effective, safer dump management techniques.

ACHIEVEMENTS A study was undertaken and a report prepared that reviewed experiences with past waste dumps at seven coal mines in British Columbia and one in Alberta. Data on failures, behaviour and operating practices were analyzed to identify patterns, correlations and unusual circumstances. Rates of failure were found to have increased markedly in the 1980's corresponding to an increased number of operations and less favourable conditions. Among the variables found to affect the risk of failure were: waste rock quality; rates of dumping; excess precipitation; steep foundation toe slopes; poor drainage, rapid loading of foundation soils and direction of crest advance. The existence of complex inter-relationships and incomplete data sets made it impossible to develop a mathematical model to simulate the relative importance of the various factors or conclude that any particular factor had become more dominant in recent years. Comments and recommendations on future monitoring procedures were included, as well as suggestions for further study.

IMPACT This study made important contributions to the understanding of factors that affect the stability of coal mine waste dumps. These waste dumps are among the largest man made structures in the world and are under increasing scrutiny because of the potential environmental

impacts of failures. The report has been a key reference for follow-up projects in 1990 to establish operating standards for waste dumps and to define critical design criteria.

OUTPUTS

Golder Associates (Western Canada) Limited (1987): *Regional Study of Coal Mine Waste Dumps in British Columbia, Stage II.*** November 1987.

Presentations were made at the following:

- Annual Meeting of the Canadian Institute of Mining and Metallurgy in Edmonton, Alberta, 1988.
- Mine Reclamation Symposium in Vernon, British Columbia, 1989.

Project name	COAL FINES AGGLOMERATION
MDA expenditures	$25,000 (1988)
Total project cost	>$50,000
Principal researcher(s)	PAL SHARMA, WESTAR MINING LIMITED, B.C. RESEARCH, FERRO-TECH LABORATORIES, CANMET, ALLIS- HALMERS LABORATORY AND KAISER ENGINEERS
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Other participating agencies	WESTAR MINING LIMITED
Project location	SOUTHEAST B.C.

OBJECTIVES To improve marketability and reduce the handling problems associated with coal from southeastern British Columbia coal mines by developing appropriate and cost-effective coal fines agglomeration technology.

ACHIEVEMENTS A comprehensive technology study was undertaken on the binding of fine coal particles from Westar's southeastern British Columbia coal operations. Laboratory tests were done by B.C. Research on agglomeration technologies and binders. Pilot scale tests were undertaken at the Ferro-Tech Laboratory in Michigan. Coking tests were done by CANMET and compacting feasibility tests by the Allis-Chalmers Laboratory in Wisconsin. The study developed a quick fix method to improve the handling characteristics of fine coal and made recommendations on a permanent solution. Also included as an additional note in the report was a description of the patented process developed by Kaiser Engineers for heavy oils application to coal fines.

IMPACT The results of this study were very useful to Westar. The coal agglomeration process developed has already been used at the Greenhills operation. It's application, however, has been minimal because of the costs involved and poor coal market conditions.

OUTPUTS

A final report was prepared that fully documented the findings of the study. Under the terms of the agreement with Westar, this report will be kept confidential until 1993.

Project name	COAL TAILINGS AGGLOMERATE
MDA expenditures	$26,500 (1988)
Total project cost	>$53,000
Principal researcher(s)	NATIONAL RESEARCH COUNCIL, CORPORATE AND TECHNICAL SERVICES AND THE EXSHAW PLANT OF CANADA CEMENT LAFARGE INCORPORATED IN ALBERTA
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Other participating agencies	CANADA CEMENT LAFARGE
Project location	SOUTHEAST B.C.

OBJECTIVES To contribute to industry knowledge by conducting a pilot test of the National Research Council's (NRC's) mobile coal agglomeration facility using coal tailings from Westar's Elkview coal preparation plant near Sparwood, British Columbia. This project was the second phase of a larger project designed to determine if a consistent and economical agglomerated product could be produced from coal tailings for use in the cement industry as kiln fuel.

ACHIEVEMENTS A pilot scale test was conducted which produced a total of 115 tonnes of agglomerated coal tailings (ACT) from Westar's Elkview Plant using the NRC's mobile unit. The resulting product was found to be acceptable as an alternate fuel source with regards to ash content and heating value. Economically, however, the production of ACT was found to be less attractive than originally predicted. The process was also found to pose additional problems concerning material handling, storage and environmental impact. In the final report, Lafarge Canada concluded that at this time it would not be feasible for the company to assume the role of both producer and consumer of ACT. They did not rule out future use of ACT as a cement kiln fuel, but stated they would only consider it from a consumer's perspective.

IMPACT The currently depressed price of domestic natural gas precluded further development of an agglomerated coal tailings product. The excellent potential of the NRC agglomeration process was demonstrated, however, and in the future, western Canadian coal producers may benefit by utilizing this process. The NRC process has since been tested at the Quintette mine.

OUTPUTS

National Research Council Canada (1988): *Waste Fine Coal Recovery Project (1987) at the Elkview Preparation Plant of Westar Mining Limited* A report prepared for Lafarge Canada Incorporated.

Corporate Technical Services and The Exshaw Plant (1988): *Lafarge Canada Incorporated The Manufacture of Agglomerated Coal Tailings (ACT) Utilizing the NRC Process and Westar Ltd's Waste Coal Tailings.*

Project name	QUICK COAL WASHABILITY TEST
MDA expenditures	$5,798 (1990)
Total project cost	$11,597
Principal researcher(s)	CROWS NEST RESOURCES LIMITED
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Other participating agencies	CROWS NEST RESOURCES LIMITED
Project location	SOUTHEAST B.C.

OBJECTIVES To improve the efficiency of British Columbia's coal mines by developing an inexpensive and quick procedure for estimating the relative plant washing characteristics of different coal seams using trench samples. This project intended to produce a fast semi-quantitative test for screening samples.

ACHIEVEMENTS Washability tests were done using trench samples from a number of seams at different pit locations at the Crows Nest Line Creek operation in southeastern British Columbia. These samples were analyzed and compared against conventional washability tests and plant performance. The results were documented in a report. The study concluded that while this method would never replace the need for a full washability test or test plant washing of a seam, it might provide useful preliminary information for very little cost or effort.

IMPACT The tests are performed on exploration samples. It is expected that in appropriate situations the results will help in the development of more detailed coal quality analysis programs. In the past year, the test has been used on exploration samples at the Line Creek coal mine in southeastern British Columbia. As well, it has received some preliminary use at other coal mining operations.

OUTPUTS

Crows Nest Resources Limited (1990): *Predicting Plant Recoveries from Small Samples.*

National Research Council's mobile coal agglomeration facility.

Project name	FOOTHILLS SURFACE GEOPHYSICS
MDA expenditures	$30,000 (1990)
Total project cost	>$180,000
Principal researcher(s)	CROWS NEST RESOURCES LIMITED, GEO-PHYSI-CON COMPANY LIMITED AND COAL MINING RESEARCH COMPANY
Supervising agency	B.C. GEOLOGICAL SURVEY BRANCH
Other participating agencies	CROWS NEST RESOURCES LIMITED, ALBERTA OFFICE OF COAL RESEARCH AND TECHNOLOGY, QUINTETTE COAL LIMITED, SMOKY RIVER COAL LIMITED, LUSCAR STERCO LIMITED AND MANALTA COAL LIMITED
Project location	NORTHWEST B.C.

OBJECTIVES To assist the coal industry by testing, evaluating and improving on the application of surface geophysical techniques for use in coal exploration in topographically and structurally complex areas.

ACHIEVEMENTS This project was conducted on Crows Nest Resources Limited's Telkwa coal licence block in northwestern British Columbia. It contributed to the Phase II work of a larger project that examined geophysical techniques in the foothills and mountains of British Columbia and western Alberta. During this study, a reflection seismic program was conducted at the Telkwa site and seismic profiles were developed. The study found that the seismic profiles successfully identified large and moderate-sized discontinuities, and confirmed prior concepts of faulting style and fault locations. As well, the profiles improved the definition of areas of non-deposition of coal. Further work, however, was identified as necessary to successfully delineate the geometry of thin, near-surface coal seams. The Phase III report will evaluate the results of all the studies undertaken in British Columbia and Alberta.

IMPACT The project has acquainted company geologists with shallow reflection seismic surveys, and has demonstrated the viability of this exploration tool in some situations. If further exploration is required on the Telkwa coal licence block, there is a good chance that they will incorporate this exploration method.

OUTPUTS

Crows Nest Resources Limited, Geo-Physi-Con Company Limited and the Coal Mining Research Company (1990): *Foothills/Mountain Surface Geophysics Project: Report of Seismic Research Conducted at Telkwa, British Columbia.*

Project name	WESTMIN ACID MINE DRAINAGE AND WASTE ROCK TREATMENT
MDA expenditures	$84,590 (1988-1990) $10,000 (Budgeted, 1991)
Total project cost	Approximately $500,000
Principal researcher(s)	NORTHWEST GEOCHEM AND WESTMIN RESOURCES LIMITED
Supervising agencies	B.C. ACID MINE DRAINAGE TASK FORCE AND B.C. ENGINEERING AND INSPECTION BRANCH
Other participating agencies	WESTMIN RESOURCES LIMITED
Project location	VANCOUVER ISLAND

OBJECTIVES To reduce the environmental impact of mining by developing a long-term, cost-effective solution to prevent and control the generation of acid mine drainage (AMD) from the waste rock at Westmin Resource's Myra Falls operation on Vancouver Island. This project intended to evaluate novel approaches for preventing AMD which would be compatible with final revegetation and decommissioning of the site and which would be applicable at other British Columbia mines.

ACHIEVEMENTS Laboratory studies and pilot tests on specially constructed waste rock test dumps at the Westmin mine site were conducted. Two approaches to preventing acid mine drainage were evaluated. One method involved

Pilot scale waste dumps and monitoring systems, Westmin Resources Ltd.

the use of bactericides to reduce the activity of the acid generating bacteria, *Thiobacillus ferrooxidans*. Early tests, however, indicated that in this case the application of bactericides would be ineffective for long-term control of AMD. The other approach looked at the use of solidification techniques to cover waste rock dumps, so as to minimize moisture and air transfer and thereby hinder acid generation. Field trials of these methods produced encouraging results. The most promising control approach involved the development of a cementitious solidification mixture incorporating mine waste materials for use as a waste rock dump surface sealant and grouting matrix. Reports were prepared which presented the results of the various phases of the program. Work is continuing on this project and final results will be produced in 1991.

IMPACT Industry interest in this project has been high. There is currently very little information available on AMD generation in waste rock dumps and this research is helping to fill the void. This project is providing a good insight into what is happening in waste dumps and interest in the use of solidifying covers has been generated.

OUTPUTS

Konasewich, D.E., Jones, C.E., Gerencher, E., and Morin K. (1990): *Hydrogeological Assessment and Development of AMD Control Technology for Myra Falls Waste Rock.* Proceedings of the Fourteenth Annual British Columbia Mine Reclamation Symposium. Cranbrook, British Columbia, June 1990.

Northwest Geochem (1988): *Study of Methods to Control Acid Generation in Waste Rock.* Submitted to the Acid Drainage Task Force of the Mineral Development Agreement Assistance Program.

Northwest Geochem (1989): *Westmin Resources Limited: Report on Study of Methods to Control Acid Generation in Waste Rock, Phase II.*

Northwest Geochem (1990): *Westmin Resources Limited: Hydrogeological Assessment and Development of AMD Control Technology for Myra Falls Waste Rock.*

Project name	KUTCHO CREEK AMD - BLENDING AND SEGREGATION
MDA expenditures	$55,000 (1989-1990) $10,000 (Budgeted, 1991)
Total project cost	Approximately $400,000
Principal researcher(s)	RESCAN ENVIRONMENTAL CONSULTANTS
Supervising agencies	B.C. ENGINEERING AND INSPECTION BRANCH AND B.C. ACID MINE DRAINAGE TASK FORCE
Other participating agencies	ESSO MINERALS CANADA, SUMAC MINES
Project location	NORTHWEST B.C.

OBJECTIVES To assist industry in mine development by investigating means of preventing and minimizing acid generation in waste rock at the Kutcho Creek deposit in northwestern British Columbia. The intent of this three year project was to determine if careful blending of waste-rock dumps would be a viable means to control AMD through the interaction of carbonate (acid consuming) and sulphide-rich (acid generating) materials.

ACHIEVEMENTS This project was conducted in three phases. During Phase I, a general reconnaissance survey of the exploration adit was done for evidence of acid generation. Representative samples of rock were collected from inside the adit and humidity cell tests were carried out on twenty samples. Phase II testing involved the construction and implementation of 3 twenty-tonne field test plots to examine whether blending acid-generating footwall wastes with acid-consuming wastes would prevent acid generation from occurring in field-scale waste dumps. Further humidity cell testwork and acid base accounting tests were also performed. Detailed monitoring of the field test plots was done in Phase III, including sampling of drainage water and collection of climatic data. Preliminary results from the laboratory humidity tests suggest that blending over the short term may minimize acid generation. From the acid base accounting tests, it was discovered that in the early stages of mine development, it may be necessary to mix limestone with the waste rock piles to increase the overall neutralization potential. Final results will be published when the study is complete.

IMPACT Industry interest in this project has been high. The blending and segregation concept is relatively new and there has not been much prior research in the area. Results from this project have already been referred to in planning for the Windy Craggy mine project in northwestern British Columbia.

As well, a very effective humidity cell was designed during the first phase of the project to test the acid-gener-

ating characteristics of the waste rock on a laboratory scale and this technique has applications in other research.

OUTPUTS

Rescan Environmental Services Limited (1989): *Kutcho Creek Property: Acid Generation Testwork Phase I Final Report.*

Rescan Environmental Services Limited (1990): *Kutcho Creek Property: Acid Generation Testwork Phase II.*

Project name	**WASTE DUMP HYDROGEOCHEMISTRY**
MDA expenditures	**$25,000 (1990)**
Total project cost	**Approximately $85,000**
Principal researcher(s)	**DR. G. POLING AND M. LI**
Supervising agencies	**B.C. ENGINEERING AND INSPECTION BRANCH AND B.C. ACID MINE DRAINAGE TASK FORCE**
Other participating agencies	**BHP-UTAH MINES LIMITED**
Project location	**NORTHERN VANCOUVER ISLAND**

OBJECTIVES To gain information on the treatment and control of acid mine drainage (AMD) by studying the waste dump hydrogeochemistry at BHP Utah's Island Copper mine on Vancouver Island. This project intended to determine the hydrogeochemistry of a waste dump through dump drilling, sampling, geochemical analysis, instrumentation and monitoring of water quality.

ACHIEVEMENTS The northwest waste dump of BHP Utah's open pit Island Copper mine was studied by means of a drilling program and using acid-base accounting and (kinetic) humidity cell testing. The interaction of rock mineralogy, bacteria population, oxygen transfer and water infiltration were monitored. Preliminary monitoring data revealed the following: the dump has probably reached a steady state; temperature changes are solely due to changes in surrounding temperatures; where oxygen concentration increases or carbon dioxide concentration decreases, Acid Producing Potential (APP) very likely increases; the dump material has a high heat preserving capacity; the dump temperature may be affected by some diffusive or convective cold air current travelling along the interface of the dump and the original ground; heat generated by sulfide oxidation contributed to the increase in the dump temperature; and, a correlation between oxygen concentration, carbon dioxide concentration and APP exists. The results were documented in a report.

IMPACT Through this project, a better understanding of the hydrogeochemistry of waste dumps was achieved. BHP Utah and government regulators were provided with information that will guide them in future reclamation efforts.

OUTPUTS

BHP - Utah Mines (1990): *Island Copper Mine: Dump Investigation Project.*

Li, M.: Final Report, which will take the form of a Master's Thesis from the University of British Columbia, is in preparation.

Project name	**CYANIDE IN GROUNDWATER**
MDA expenditures	**$16,000 (1990)**
Total project cost	**>$32,000**
Principal researcher(s)	**L. BROUGHTON**
Supervising agency	**B.C. MINERAL POLICY BRANCH**
Other participating agencies	**KLOHN LEONOFF CONSULTING ENGINEERS, COASTECH RESEARCH INCORPORATED**
Project location	**PROVINCE-WIDE**

OBJECTIVES To provide practical information to the mining industry and regulatory authorities regarding the fate and persistence of cyanide in groundwater. This project intended to develop a standard test procedure for determining the behavior of cyanide in different soils and using this procedure, to test the attenuation capabilities of soils typical in British Columbia at specific sites.

ACHIEVEMENTS A summary report documenting current research and knowledge about the behavior of cyanide in the environment was prepared. Selected soil samples were collected from Corona's Nickel Plate mine, Cheni-Corporation's Lawyer's mine and Sumac Venture's Grand Forks Heap Leach operation. These sites were chosen because they represent three different types of gold milling and cyanide solution containment facilities. Laboratory soil characterization and column testing were done on the samples to determine the attenuation capabilities of the soils. The final report will document the results of the study.

IMPACT Identification of the major factors that affect the behavior of cyanide in groundwater, and definition of attenuation capacities for at least some soils within British Columbia will be useful tools both for the development of new cyanide impoundments and monitoring and remediation of existing operations.

OUTPUTS

Broughton, L.M. (1990): *The Fate And Persistence Of Cyanide In Groundwater: Progress Report No. 1.*

Project name	FRASER RIVER GRAVEL STUDY
MDA expenditures	$5,000 (1990)
Total project cost	>$15,000
Principal researcher(s)	NORTHWEST HYDRAULIC CONSULTANTS LIMITED
Supervising agency	FISHERIES & OCEANS CANADA - HABITAT MANAGEMENT UNIT AND B.C. ENGINEERING AND INSPECTION BRANCH
Other participating agencies	AGGREGATE PRODUCERS OF B.C. AND THE DISTRICT OF CHILLIWACK.
Project location	LOWER FRASER RIVER

OBJECTIVES To provide industry and government with a better understanding of the physical impacts of gravel mining operations on the lower Fraser River. This project intended to review and assess the impacts of past gravel mining operations near Minto Landing and comment on approaches that could be used to minimize bar scalping impacts at new operations.

ACHIEVEMENTS A report was produced that describes the physical characteristics of the Fraser River near Minto Landing and its evolution over the last century. Available data on past gravel mining operations and the mining methods used (either bar scalping or instream excavation) in Minto side channel are summarized. Based on this data, an assessment of past dredging operations on the river's regime was produced. The report concludes that due to the particular site characteristics of the two ongoing scalping operations, no substantial upstream or downstream morphologic impacts have occurred. Several areas in the side channel were identified where additional bar scalping could be carried out with minimal impacts to the adjacent channel morphology. The report recommends that Fisheries and Oceans introduce the following two restrictions on gravel mining to reduce the effects of instream excavations: 1) specify a maximum allowable excavation depth and the total quantity of gravel that can be removed, and 2) re-direct operations to isolated areas of the channel.

IMPACT This project has provided useful information on the effects of gravel mining on the Fraser River. Additional bar scalping sites were identified, which could be developed as part of a habitat enhancement program. Along with the information from an earlier study, the Department of Fisheries and Oceans Canada now has a better understanding and a greater amount of background data available to help in assessing the impacts of future operations.

OUTPUTS

Northwest Hydraulic Consultants Limited (1990): *Review of Gravel Mining on River Regime: Fraser River near Minto Landing.*

1.3.4 Mineral Supply Forecasting

Project name	COMMODITY RESEARCH UNIT REPORTS
MDA expenditures	$38,500 (1987-1989)
Principal researcher(s)	COMMODITY RESEARCH UNIT
Supervising agency	B.C. MINERAL POLICY BRANCH
Other participating agencies	B.C. MINERAL POLICY BRANCH
Project location	VICTORIA

OBJECTIVES To support the Ministry's forecasting and planning activities by purchasing regular and special reports on world metal markets from the Commodity Research Unit (CRU) of London, England.

ACHIEVEMENTS MDA funding contributed towards the purchase of CRU reports on the following topics: short-term and 5 year outlooks for copper, lead, zinc and molybdenum markets; production costs for North America copper mines; and an analysis of the copper concentrate trade.

IMPACT These reports have provided the Ministry with market intelligence information useful for policy analysis and planning. In addition to providing information relevant to daily work, the data has been particularly useful in the preparation of the Mineral Market Update and for the work of the Mine Closure Task Force.

OUTPUTS

Off-the-shelf metal market information is available to the Ministry in the form of hard copy reports maintained in the Mineral Policy Branch Library.

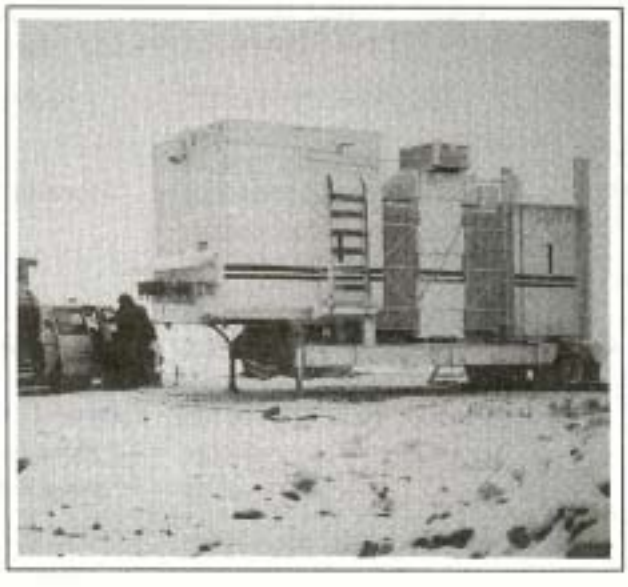
1.3.5 R & D Fund

Project name	ELECTRIC SHOCK HAZARD STUDY
MDA expenditures	$32,036 (1989)
Principal researcher(s)	BENSTED, SIMPSON & ASSOCIATES LIMITED
Supervising agency	B.C. ENGINEERING AND INSPECTION BRANCH
Project location	PROVINCE-WIDE

OBJECTIVES To increase safety in the mining industry by examining the safety problems related to the use of portable electric substations in open pit mines in British Columbia. This objective was to be achieved by studying the grounding conditions at selected mines and developing guidelines for the safe use of this type of equipment.

ACHIEVEMENTS Field trips were made to five open pit mines in British Columbia, where a series of soil resistivity and ground system impedance measurements were carried out. Information and measurement results that had previously been obtained from another mine were also made available for this study. The field measurement data were processed; the power system information reviewed; fault level calculations carried out; and possible fault situations developed. A report was prepared which showed the results of the study and assessed the potential for shock hazard at each of the sites. Recommendations to ensure greater safety and a code of practice for the use of moveable substations at each site were also presented.

IMPACT The results of this study are forming a basis for revisions to the Canadian Standards Association for Use of Electricity in Mines.



Moveable substation for open-pit mines.

OUTPUTS

Bensted, Simpson & Associates Limited, King, R.F., & Bromley, D.A. (1989): Electric Shock Hazards Associated With Moveable Mine Substations. A Paper presented at the Mechanical Electrical Symposium in Victoria, British Columbia, 1989.

Bensted, Simpson & Associates Limited, (1989): Ground Mat and Soil Resistivity Testing. A Paper presented at the Mechanical Electrical Symposium in Victoria, British Columbia, 1989.

Bensted, Simpson & Associates Limited (1989): *Study of Mining Shock Hazards*. BSA Project No: 4137.**

Project name	EXPLORATION SAFETY SEMINAR
MDA expenditures	$1,000 (1990)
Principal researcher(s)	SAFETY COMMITTEE OF THE B.C. AND YUKON CHAMBER OF MINES
Supervising agency	B.C. MINERAL POLICY BRANCH
Other participating agencies	BRITISH COLUMBIA AND YUKON CHAMBER OF MINES
Project location	VANCOUVER

OBJECTIVES To increase safety in the mining industry by producing a safety seminar for personnel involved in mineral exploration in British Columbia.

ACHIEVEMENTS A one day safety seminar was conducted on March 20, 1990. It addressed common safety themes such as: safe vehicle practices, hypothermia, mountain and glacier travel, aircraft safety, wilderness survival and first aid, dangerous animals, safe practice in underground and surface mine workings and considerations for back and eye safety.

IMPACT This project has resulted in increased awareness of safety procedures for individuals working in mineral exploration in British Columbia.

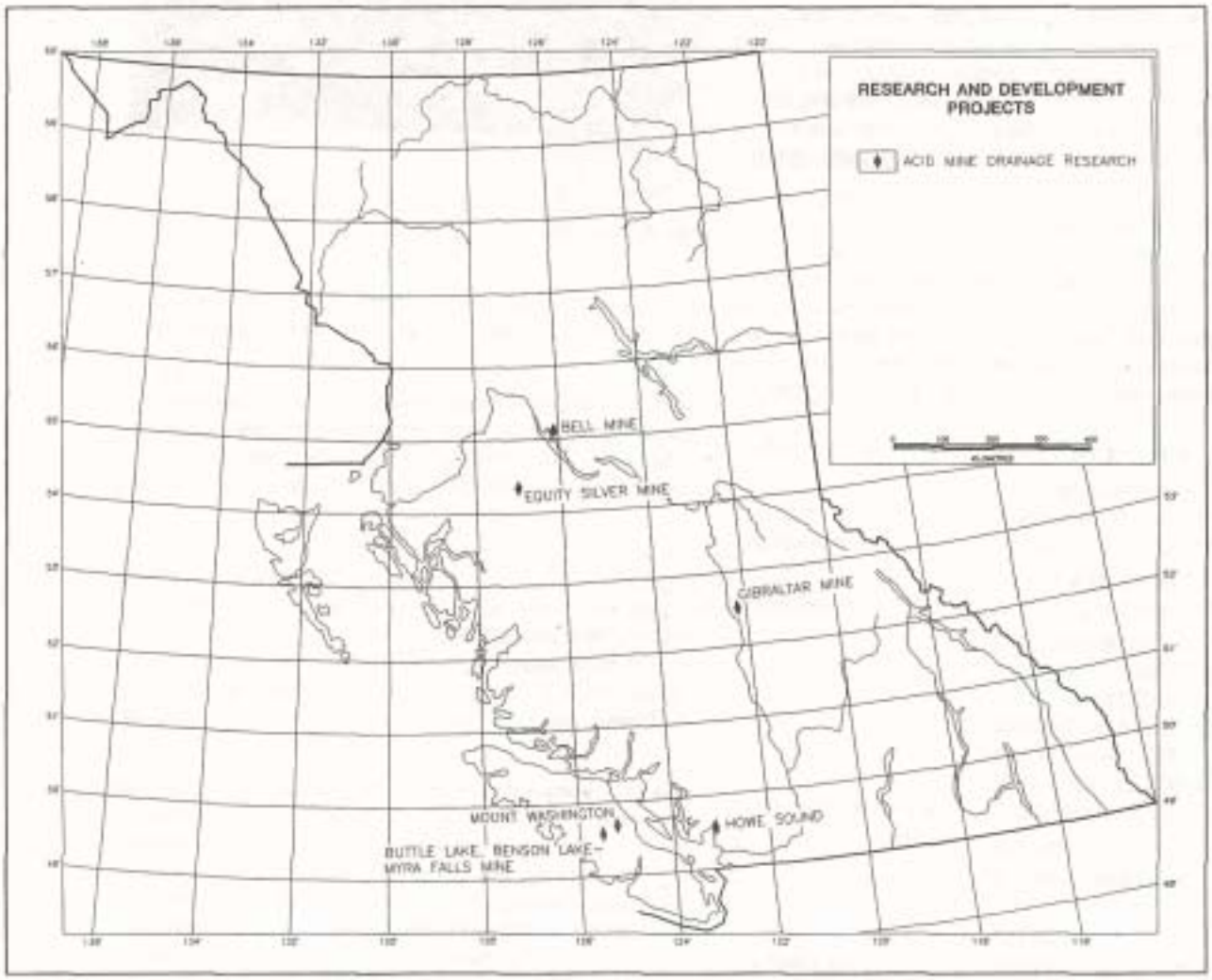
OUTPUT

Third Exploration Safety Seminar. Vancouver, British Columbia, 1990.

Project name	**MT. WASHINGTON INSTRUMENTATION AND DATA SUMMARY**
MDA expenditures	**$13,462 (1989-1990)**
Total project cost	**Approximately $440,000 (1988-1989)**
Principal researcher(s)	**STEFFEN, ROBERTSON AND KIRSTEN (B.C.) INCORPORATED AND T. SCHWAB**
Supervising agency	**B.C. ENGINEERING AND INSPECTION BRANCH**
Other participating agencies	**B.C. MINISTRY OF THE ENVIRONMENT, ENVIRONMENT CANADA**
Project location	**VANCOUVER ISLAND**

OBJECTIVES To provide a better understanding of the means of controlling acid mine drainage by studying and monitoring the acid mine drainage abatement techniques applied at the abandoned Mount Washington copper mine on Vancouver Island. The project intended to collect and present hydrologic, geologic and topographical information from the site.

ACHIEVEMENTS Through these projects, MDA funding contributed to the first two years of a multi-year project. During 1989, the glacial till blanket construction phase was completed, along with the construction of a 310 metre diversion ditch and the installation of fourteen piezometers. Seeding and fertilizing of the waste dump was also completed, and a program was set up to monitor the physical and chemical hydrogeology of the mine site and waste dump and to evaluate the effectiveness of the reclamation activities already undertaken. MDA funding was primarily responsible for the installation of instruments to monitor the impact of reclamation on water quality.



During the second year, site plans were produced that plotted groundwater and geochemical data. The data indicated that the effectiveness of the glacial till cover on the East Dump was not proven or disproven, due to the impact of drainage from the pit on the East Dump. The blanket of mine waste was shown to be subject to an unusually high and variable water table that was considered to have experienced a significant production of acid and metals.

IMPACT The results of the monitoring program provided an improved analysis of AMD generation and the impact of abatement techniques. They have been used to guide the subsequent control program. As well, the site plans and cross section generated provided a base for the design of the final control work.

OUTPUTS

Galbraith, M. (1990): Mount Washington Acid Rock Mine Reclamation Project. A paper presented at the Fourteenth Annual British Columbia Mine Reclamation Symposium in Cranbrook, British Columbia, June 1990.

A presentation was made at the Canadian Institute of Mining and Metallurgy Meeting in Penticton, British Columbia in 1989.

Site plans and cross-sections were produced that plotted groundwater and geochemical data.

Mount Washington.

Project name	AMD TECHNOLOGY GUIDE
MDA expenditures	$70,163 (1989-1990)
Total project cost	$78,183
Principal researcher(s)	STEFFEN, ROBERTSON AND KIRSTEN (B.C.) INCORPORATED, NORECOL ENVIRONMENTAL CONSULTANTS AND GORMELY PROCESS ENGINEERING
Supervising agency	B. C. ACID MINE DRAINAGE TASK FORCE
Other participating agencies	ENERGY MINES AND RESOURCES CANADA AND ENVIRONMENT CANADA
Project location	PROVINCE-WIDE

OBJECTIVES To provide mining companies, consultants and regulatory agencies with an understanding of the process of acid mine/rock drainage (AMD) and guidance on the application of AMD abatement technology. This objective was to be achieved by producing a standard reference manual outlining the state of the art technology for prediction, prevention, treatment, control and monitoring of AMD.

ACHIEVEMENTS MDA funding contributed towards the production of the first volume of a two volume technical guide that describes the acid generation and metal leaching and migration processes. Current methods for prediction, prevention, treatment, control and monitoring of AMD are outlined and assessed. Recommended procedures to deal with AMD problems are presented.

IMPACT Awareness of acid mine/rock drainage was heightened by this project. Since the publication of the guide, two short courses based on the guide's contents have been offered in Vancouver and one in Ontario. Other courses elsewhere in Canada and in Indonesia have used the guide as a textbook.

OUTPUTS

Steffen, Robertson and Kirsten (B.C.) Incorporated, Norecol Environmental Consultants and Gormely Process Engineering (1989): *Draft Acid Rock Drainage Technical Guide*. Volume I.**

Steffen, Robertson and Kirsten (B.C.) Incorporated, Norecol Environmental consultants and Gormely Process Engineering (1989): *Draft Acid Rock Drainage Technical Guide*. Volume II.**

Project name	UNDERWATER DISPOSAL
MDA expenditures	$99,814 (1989-1990) $10,000 (Budgeted 1991)
Total project cost	>$200,000
Principal researcher(s)	RESCAN ENVIRONMENTAL CONSULTANTS
Supervising agency	B.C. ACID MINE DRAINAGE TASK FORCE
Other participating agencies	MINE ENVIRONMENT NEUTRAL DRAINAGE COMMITTEE, CANMET AND ENVIRONMENT CANADA
Project location	VANCOUVER ISLAND

OBJECTIVES To gain knowledge on the prevention of acid mine drainage (AMD) by determining the criteria for environmentally safe disposal of reactive mine wastes in fresh water environments. This project intended to evaluate the effectiveness of underwater disposal methods for suppressing acid generation from mine waste rock and tailings in Buttle Lake and Benson Lake on Vancouver Island as part of a Canada-wide study through the Mine Environment Neutral Drainage Committee.

The effectiveness of underwater disposal methods for environmentally safe disposal of mine wastes were evaluated.

ACHIEVEMENTS This project represents the first detailed study of the distributions of metals in both the solid phases and interstitial waters of the abandoned tailings deposits in Buttle Lake and Benson Lake. Water quality sampling, CTD profiling and lake sediment coring for pore water analyses were conducted. The results from the first phase found that the potentially reactive mine tailings submerged in the south basin of Buttle Lake made no significant impact on the water quality of the area. Similar studies on Benson Lake are being undertaken during the 1990 season.

IMPACT The positive results obtained to date are confirming for the mining industry and regulatory agencies that the use of underwater disposal of mining wastes as a means to prevent the formation of AMD may be an acceptable alternative.

OUTPUTS

Rescan Environmental Consultants (1989): *Subaqueous Disposal of Reactive Mine Wastes; An Overview*. Report to the Acid Mine Drainage Task Force.

Rescan Environmental Consultants (1990): *Geochemical Assessment of Subaqueous Tailings Disposal in Buttle Lake, British Columbia*. A British Columbia Acid Mine Drainage Task Force Project in Contribution to MEND (Mine Environment Neutral Drainage).

Project name	PREDICTION: OPEN PITS
MDA expenditures	$20,850 (1990)
Total project cost	>$50,000
Principal researcher(s)	K. MORIN/MORWIJK ENTERPRISES LIMITED
Supervising agency	B.C. ACID MINE DRAINAGE TASK FORCE
Other participating agencies	EQUITY SILVER MINES LIMITED
Project location	WEST CENTRAL B.C.

OBJECTIVES To provide industry and government with a computer model that would simulate and predict the potential for acid drainage from mine walls in open pits following mine closure. This objective was to be achieved by analyzing a comprehensive existing data set for Equity Silver mine in west central British Columbia.

ACHIEVEMENTS A report was produced that consisted of a literature review; an evaluation of site data; a predictive model of acid mine drainage (AMD) during operation, flooding, and after decommissioning; and a set of recommendations for further studies and for draft criteria for pit abandonment.

As well, a computer program, MINEWALL, was developed based on conceptual models that accounted for water

movement, acid generation, acid neutralization, and metal leaching through time within a mine. MINEWALL was applied to the Equity Silver mine and the program predicted the Main Zone Pit would remain non-acidic throughout decommissioning, except for an initial mild acid flush at the beginning of flooding.

IMPACT The capability to evaluate and predict the water-quality impacts of open pit mines has been greatly enhanced because of this project. Further work was indicated as necessary to more fully examine the mechanisms that control AMD production in open pits.

OUTPUTS

Morwijk Enterprises Limited (1990): *Acid Drainage from Mine Walls: The Main Zone Pit at Equity Silver Mine.*

Morwijk Enterprises Limited (1990): MINEWALL. A computer program.

Project name	GIBRALTAR AMD MODEL
MDA expenditures	**$15,140 (1990)**
	$10,000 (Budgeted, 1991)
Total project cost	**Approximately $400,000**
Principal researcher(s)	KLOHN LEONOFF LIMITED
Supervising agency	B.C. ACID MINE DRAINAGE TASK FORCE
Other participating agencies	GIBRALTAR MINES LIMITED
Project location	CENTRAL B.C.

OBJECTIVES To study methods for treatment and control of acid mine drainage (AMD) by developing an AMD model that would predict the effect of commercial leaching activities on long term water quality following mine closure. This objective was to be achieved by monitoring the effects of economic leaching activities at the Gibraltar mine in central British Columbia.

ACHIEVEMENTS Only the first two years of this five year project received funding through the Mineral Development Agreement. During this phase, a literature search was conducted of other bioleach operations. Information on prediction, mineralogy, water quality and other data related to Gibraltar was reviewed and assessed. Recommendations were presented for further work to acquire additional data for long term prediction. A report documenting results to date was produced. Work during the 1990 season was based on the recommendations of the report.

IMPACT This project will provide important information on the long term effects of commercial leaching of mine dumps. Possible treatment methods following economic extraction will be tested and a model of the leach process within a dump will be developed.

OUTPUTS

Klohn Leonoff Limited (1990): *Gibraltar Mines Limited: Drainage Project, Review and Assessment Study.*

Project name	CONSTRUCTED WETLAND: BELL MINE
MDA expenditures	**$22,464 (1990)**
	$10,000 (Budgeted, 1991)
Total project cost	**Approximately $276,000**
Principal researcher(s)	GORMELY PROCESS ENGINEERING
Supervising agency	B.C. ACID MINE DRAINAGE TASK FORCE
Other participating agencies	NORANDA MINERALS INCORPORATED
Project location	CENTRAL B.C.

OBJECTIVES To advance wetlands technology as a means for treatment and control of acid mine drainage (AMD). This project intended to design, construct and monitor the performance of an artificial wetland as a downstream passive treatment system for AMD at the Bell Copper mine in central British Columbia.

ACHIEVEMENTS Mineral Development Agreement assistance was provided for the first two years of this four year study. During this phase an artificial wetland at the Bell mine site was designed and constructed. Tests were conducted to assess the following: the efficiency of the wetland for metal removal on a seasonal basis; the sensitivity of the system to fluctuating flows and metal concentrations; the capacity of the wetland to absorb metals; and the stability of the precipitated metals. Final results will be published when the project is complete.

IMPACT This project will contribute towards a greater understanding of the use of wetlands as a means of controlling metal-laden effluent at mine sites. It will provide one of the first examples of wetland use in a northern climate. If successful, the industry applications are widespread.

OUTPUTS

Gormely Process Engineering: Report in preparation.

Project name	OPTIMUM SAMPLING FREQUENCY
MDA expenditures	$25,697 (1990)
Principal researcher(s)	E. ROBERTSON
Supervising agency	B.C. ACID MINE DRAINAGE TASK FORCE
Project location	PROVINCE-WIDE

OBJECTIVES To recommend the optimum sampling frequency for assessing water quality in effluent caused by acid mine drainage (AMD). This object was to be achieved by evaluating four of the most extensive water quality monitoring data sets associated with AMD in British Columbia.

ACHIEVEMENTS A review of the main literature on sampling theory was undertaken. Monitoring programs at several mine sites in British Columbia were evaluated and deficiencies in current programs identified. The project attempted to determine the number of samples necessary to reliably detect the beginning of an AMD problem, evidence of environmental damage and changes in water chemistry. Recommendations will be presented in the final report on strategies for design of monitoring programs.

IMPACT This project could change monitoring program designs throughout the industry. It will impact on monitoring requirements for permits and approvals. Improvements in program design, reliability and cost effectiveness should result.

OUTPUTS

Robertson, E. (1990): *Optimum Sampling for Acid Mine Drainage Monitoring*

Project name	BIOLOGICAL MONITORING OF AMD
MDA expenditures	$20,319 (1990)
Principal researcher(s)	E.V.S. CONSULTANTS LIMITED
Supervising agency	B.C. ACID MINE DRAINAGE TASK FORCE
Project location	PROVINCE-WIDE

OBJECTIVES To determine the most effective method for biological monitoring of acid mine drainage (AMD) by reviewing existing methods and assessing and recommending the best techniques.

ACHIEVEMENTS A literature review was compiled revealing that the most promising and proven biological monitoring techniques included benthic community responses; growth and reproductive parameters of fish populations; survival in a designated zone of impact; and other changes at the individual, biochemical level. It was determined that no single approach would completely supply all of the required information. The most cost-effective approach to assessing ecosystem health in waters affected by AMD was found to involve a multi-disciplinary, "top-down" approach, that relied on the detection of impacts before they became irreversible.

IMPACT This project will assist in conducting more precise evaluations of the environmental effects of AMD. As well, it will help to identify what level of treatment and what quality of effluent is necessary to protect the environment.

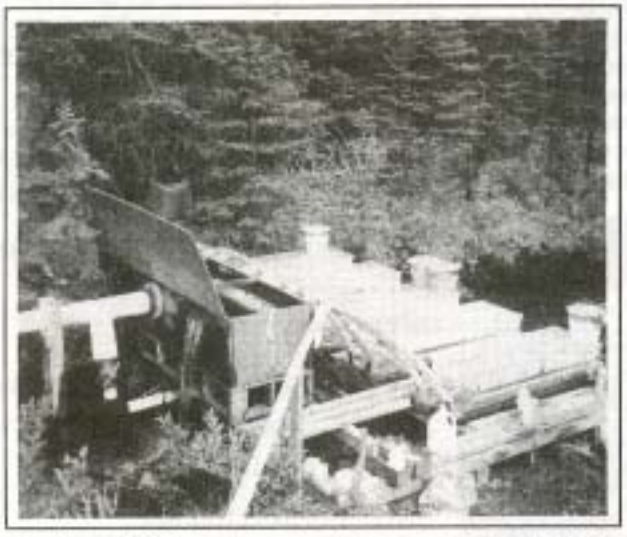
OUTPUTS

E.V.S. Consultants Limited (1990): *Literature Review for Biological Monitoring of Heavy Metals in Aquatic Environments.*

Project name	AQUATIC INVERTEBRATES MONITORING
MDA expenditures	$40,000 (1990) $40,000 (Budgeted, 1991)
Total project cost	Approximately $130,000
Principal researcher(s)	LIMNOTEK RESEARCH & DEVELOPMENT INCORPORATED
Supervising agency	B.C. ACID MINE DRAINAGE TASK FORCE
Other participating agencies	LIMNOTEK RESEARCH & DEVELOPMENT INCORPORATED AND B.C. MINISTRY OF THE ENVIRONMENT
Project location	WEST CENTRAL B.C.

OBJECTIVES To evaluate the use of a trough apparatus for measuring the environmental effects of dilute acid mine drainage (AMD) on aquatic invertebrates. This project used a trough apparatus on Foxy Creek, near the Equity Silver mine site in west central British Columbia, and test it with an initial run using a preselected concentration of dilute or treated AMD. Stage II plans are to use the trough apparatus to test raw AMD at different dilutions and expose fish as well as invertebrates.

ACHIEVEMENTS An apparatus consisting of 10 flow-through troughs, suitable for invertebrate and periphytic algal colonization and growth were installed and tested on Foxy Creek. Samples were taken from 5 treated and 5 untreated troughs during and at the end of a 6 week experiment for examination of the effects of AMD additions on indices of invertebrate abundance and algal growth.



Near Equity Silver mine a trough apparatus was tested to measure the environmental impacts of mining.

Results from the first stage showed that at the operational 10 % AMD dilution rate, the addition of treated AMD to Foxy Creek did not impact on aquatic insect composition and abundance. The apparatus was observed to be a powerful tool capable of accurately determining ecosystem response curves for effluent discharges during mine operations or at closure. As well, it was found to be ideal for exploring alternative AMD treatment strategies at specific sites. Stage II of the project was conducted during the summer of 1990.

IMPACT Industry interest in this project has been high. Limnotek Incorporated has already been contacted by other companies and will be using the trough apparatus to determine environmental impacts at other mine sites during 1991.

OUTPUTS

Limnotek Research and Development Incorporated (1990): *The Effect of Additions of Treated Acid Mine Drainage on the Abundance and Composition of Stream Macroinvertebrates and Periphytic Algae: An In Situ Mesocosm Experiment.*

Project name	AMD SEDIMENT MONITORING
MDA expenditures	$4,998 (1990)
Principal researcher(s)	E.V.S. CONSULTANTS LIMITED
Supervising agency	B.C. ACID MINE DRAINAGE TASK FORCE
Project location	PROVINCE-WIDE

OBJECTIVES To determine the relevance and applicability of sediment monitoring techniques for measuring the impact of acid mine drainage (AMD). The intent was to undertake an extensive literature review in order to provide information and guidance on sediment contamination issues.

ACHIEVEMENTS A literature review of sediment monitoring techniques was conducted. A report was prepared recommending the application of the Sediment Quality Triad approach for acid mine sites. This method is an effects-based approach to evaluating and assessing pollution-induced degradation due to toxic sediments. It was developed to utilize three measures of sediment quality: sediment chemistry, which measures contamination; sediment bioassay, which measures toxicity; and biological community structure, which measures biological alteration. The Triad effectively combines the information from independent measures into an interpretive framework.

IMPACT This project will help to clarify the impact of AMD releases on the environment and will act as a guide for future monitoring work.

OUTPUTS

E.V.S. Consultants (1990): *Review of Sediment Monitoring Techniques.*

Project name	DIAGENESIS IN AQUATIC TAILINGS
MDA expenditures	$4,000 (1990)
Total project cost	$10,000
Principal researcher(s)	K. DRYSDALE
Supervising agency	B.C. ENGINEERING AND INSPECTION BRANCH AND B.C. ACID MINE DRAINAGE TASK FORCE
Other participating agencies	B.C. MINISTRY OF ENERGY, MINES & PETROLEUM RESOURCES
Project location	HOWE SOUND

OBJECTIVES To investigate the long term stability of reactive tailings in a submarine environment. This objec-

tive was to be achieved by examining the pore water composition of historical tailings derived from sulfide-rich ores at the Britannia mine when deposited in a marine environment.

ACHIEVEMENTS This study found surface enrichments of base metals were being diluted by natural sedimentation from the Squamish River. The oxygen diffusing into the sediment from the overlying water was completely consumed by 7 cm depth in the lower basin and by 3 cm in the upper basin. Dissolved sulfides were found to be virtually absent, despite active sulfate reduction close to the sediment/water interface. The presence of the thin oxygenated layer indicated that the bulk of the metal rich tailings deposit lay within the sulfate reducing zone, which was likely to render it generally unreactive and insoluble.

IMPACT The abandoned Britannia mine is a significant source of metals to Howe Sound. This study confirms that the tailings are not a significant source of this contamination and efforts can and are being concentrated on the on-land sources, such as mine waters and waste rock.

OUTPUTS

Drysdale, K. (1990): *Geochemical Behavior of a Buried Marine Mine Tailing Deposit, Howe Sound.*

Project name	ION SPECIATION MODEL
MDA expenditures	**$11,000 (Budgeted, 1991)**
Principal researcher(s)	C.B. RESEARCH INTERNATIONAL CORPORATION
Supervising agency	B.C. ACID MINE DRAINAGE TASK FORCE
Project location	PROVINCE-WIDE

OBJECTIVES To provide a more concise understanding of the aquatic impacts of acid mine drainage by refining the ion speciation model MINEQL to include determination of metal complexes with natural organic matter substances.

ACHIEVEMENTS None to date. A report and a computer disk copy of the speciation model will be submitted by December 31, 1990.

IMPACT None to date.

PROGRAM II

2. Financial Assistance for Mine Development

The purpose of this program was to provide financial assistance on a cost-shared basis to industry for engineering design and environmental studies for mine access roads.

The provision of infrastructure was determined to be key to the development of some of the province's more remote and potentially valuable orebodies. With the necessary infrastructure in place, several proposed projects could be developed that would generate new jobs in remote areas. As well, with the availability of road access and other facilities, additional jobs in mineral exploration and other resources industries could be stimulated.

Infrastructure assessments for six mine developments were carried out. Total expenditures under this Program reached approximately $1,100,000.

Three of the six access roads have now been constructed - to the Lawyers gold-silver mine, the Nickel Plate gold-silver mine and the Golden Bear gold-silver mine. Two other proposals are currently under review by the provincial Mine Development Steering Review Process.

Project name	MT. KLAPPAN PRE-ENGINEERING STUDY
MDA expenditures	$12,000 (1986)
Total project cost	Approximately $69,800
Principal researcher(s)	PHILLIPS BARRATT KAISER ENGINEERING
Supervising agency	B.C. ENGINEERING AND INSPECTION BRANCH
Other participating agencies	GULF CANADA RESOURCES LIMITED AND B.C. MINISTRY OF THE ENVIRONMENT
Project location	NORTHWEST B.C.

OBJECTIVES To assist with the feasibility assessment of the Mount Klappan anthracite coal project in northwestern British Columbia by providing support for infrastructure planning. This project intended to identify and assess all potential road corridors to the mine site, make recommendations on the most practical route, and prepare preliminary route alignments and capital and maintenance cost estimates.

ACHIEVEMENTS An engineering and geotechnical review of road corridors was prepared. Recommendations on the most practical route were presented, based on field reconnaissance, mapping and technical reviews. Preliminary route alignments within these corridors and preliminary construction costs were estimated.

IMPACT This study helped to identify the optimal route to the proposed Mount Klappan mine site.

OUTPUTS

Phillips Barratt Kaiser Engineering Limited (1985): *Phase A: Preliminary Corridor Assessment Access Road Study.*

Phillips Barratt Kaiser Engineering Limited (1985): *Mount Klappan Access Road Study Phase B: Analysis of Selected Routes.*

Project name	MT. KLAPPAN DETAILED STUDY
MDA expenditures	$595,063 (1986-1987)
Total project cost	>$600,000
Principal researcher(s)	PEDOLOGY CONSULTANTS, M. MILES & ASSOCIATES CONSULTANTS LIMITED, T. HARDING, D. BUSTARD, SHIP ENVIRONMENTAL CONSULTANTS LIMITED, D.A. BLOOD & ASSOCIATES, C. CLEMENT, SHEARWATER ECOLOGICAL SERVICES, JUAN DE FUCA ENVIRONMENTAL CONSULTANTS LIMITED, BASTION GROUP, WILLIS CUNLIFFE TAIT/DELCAN, THURBER CONSULTANTS.
Supervising agency	B.C. ENGINEERING AND INSPECTION BRANCH
Other participating agencies	GULF CANADA RESOURCES LIMITED
Project location	NORTHWEST B.C.

OBJECTIVES To further investigate the feasibility of developing the Mount Klappan anthracite coal deposit by undertaking a detailed engineering study of the previously selected road corridor, with attention given to environmental considerations, other natural resources, regional hydrology, terrain, availability of electric power and other related factors.

ACHIEVEMENTS Detailed engineering and environmental assessment studies were conducted of the proposed access road. Separate consultants prepared environmental impact reports for the following resources: terrain, vegetation, fluvial geomorphology, fisheries, wildlife, outdoor recreation and visual impacts, and heritage value. The characteristics of resources within an approximate 2 kilometre-wide corridor were documented. Independent assessments of the potential impacts of road development on these resources were presented and possible ways to avoid or lessen some of the initially identified environmental impacts suggested. The report concluded that there were no significant direct environmental impacts associated with the construction, operation and maintenance of the road and that the identified environmental impacts could be remedied with straight-forward solutions.

IMPACT This project greatly assisted Gulf Canada Resources Limited with its plans for development.

OUTPUTS

Pedology Consultants (1986): *Mount Klappan Access Road Study, Stage II Impact Assessment, Volume I Report.* A report prepared for The Province of British Columbia Ministry of Energy, Mines and Petroleum Resources and Gulf Canada Corporation.

Project name	ANTHRACITE MARKET STUDY
MDA expenditures	$22,997 (1987)
Total project cost	
Principal researcher(s)	JAMIESON RESOURCES
Supervising agency	B.C. MINERAL POLICY BRANCH
Project location	NORTHWEST B.C.

OBJECTIVES To provide an independent appraisal of anthracite market conditions in order to assist government in assessing the viability of further financial support for Mount Klappan anthracite coal project infrastructure requirements.

ACHIEVEMENTS A study was produced that provided a quick overview of the world anthracite supply situation, with special emphasis on the situation in Western Europe where it was known that a large number of established high price markets were concentrated, as opposed to the bulk, low price markets available in the Far East.

IMPACT This study has served as input into decision-making regarding government financial support for the infrastructure requirements of Gulf Canada Resources Limited's proposed Mount Klappan anthracite coal project. As of December 1989, the Mount Klappan project has remained in Stage II of the provincial Mine Development Review Process. The company has placed the project on hold indefinitely, pending the development of markets and long term contracts.

OUTPUTS

Jamieson Resources (1987): *International Anthracite Production and Supply Study.* Under the terms of an agreement between the Ministry and the company, this study will remain confidential indefinitely.

Project name	GOLDEN BEAR TRANSPORTATION OPTIONS I
MDA expenditures	$6,250 (1988)
Total project cost	$12,500
Principal researcher(s)	URBAN SYSTEMS LIMITED
Supervising agency	B.C. ENGINEERING AND INSPECTION BRANCH
Other participating agencies	NORTH AMERICAN METALS INCORPORATED
Project location	NORTHWEST B.C.

OBJECTIVES To assist in the development of a gold deposit in an isolated area of northwestern British Columbia. This project intended to determine the safest, most cost-effective and environmentally responsible transportation option to service the proposed Golden Bear mine site.

ACHIEVEMENTS An overview study was prepared of transportation options for meeting the needs of the Golden Bear project. The four options reviewed were: air only, winter haul road/air support, all-weather road, and summer haul road. These options were evaluated on the basis of technical feasibility, capital and operating cost/impact on project feasibility, employee safety and convenience, and socio-economic and community impact. Based on this analysis, the report concluded that the all-weather road was the most technically feasible option. The main reasons for this choice were lack of major technical constraints, lower costs and reliability of the all-weather road option. The report further concluded that the route known as the Moosehorn route would likely be the preferred option among several from a technical, environmental and cost perspective.

IMPACT Based on these reports the decision was made that the mine proponent should concentrate future detailed engineering and environmental design efforts on developing an acceptable final alignment in the Moosehorn corridor.

OUTPUTS

Urban Systems Limited (1987): *Overview of Transportation Options for the Proposed Golden Bear Mine.*

Project name	GOLDEN BEAR ACCESS ROAD
MDA expenditures	$173,735 (1988)
Total project cost	Approximately $350,000
Principal researcher(s)	T.M. THOMPSON AND NORECOL CONSULTANTS LIMITED
Supervising agency	B.C. ENGINEERING AND INSPECTION BRANCH
Other participating agencies	NORTH AMERICAN METAL INCORPORATED
Project location	NORTHWEST B.C.

OBJECTIVES To facilitate development of the Golden Bear gold-silver mine in northwestern British Columbia by conducting further studies to confirm the technical and environmental acceptability of the Moosehorn Route.

ACHIEVEMENTS Engineering and environmental field studies were carried out which covered route alignment, plan profiles, stream crossing designs, and fisheries/wildlife/heritage resource assessments. Unfortunately, detailed studies revealed major fish values for which adequate protection could not be afforded, plus a wide range of wildlife habitat encroachments which were considered unacceptable to provincial and federal environmental agencies and the Tahltan Tribal Council.

IMPACT The result of the detailed engineering and environmental design work was that the Moosehorn route was ruled out and a search began for an alternative, more environmentally acceptable route.

OUTPUTS

Norecol Consultants Limited (1987): *Analysis of Transportation Options for the Golden Bear Project.*

Project name	GOLDEN BEAR TRANSPORTATION OPTIONS II
MDA expenditures	$22,499 (1988)
Principal researcher(s)	THURBER CONSULTANTS LIMITED
Supervising agency	B.C. MINERAL POLICY BRANCH
Project location	NORTHWEST B.C.

OBJECTIVES To assist in the development of the Golden Bear mine by undertaking an independent assessment of the access route that was proposed by the mine proponent (the Moosehorn route), and evaluating other possible road corridor options which were not looked at in earlier studies.

ACHIEVEMENTS A report was prepared which compared six corridor options from the following perspectives: travel time, traffic safety, engineering, geotechnical problems, and construction, operating and maintenance costs. Following this detailed review, all parties, the Mine Development Steering Committee, the Department of Fisheries and Oceans, the Tahltans, and the mining company endorsed the "Modified Lower Tahltan Route." The Environmental Land Use Committee granted Approval in Principal to the project in early March, 1988.

IMPACT This report led to the successful resolution of outstanding routing concerns. The route was successfully constructed in the 1988-89 field season.

OUTPUTS

Thurber Consultants Limited (1988): *Golden Bear Access Road Technical Assessment of Alternative Corridors.*

Project name	SEREM/LAWYERS
MDA expenditures	$116,762 (1986 - 1987)
Total project cost	Approximately $230,000
Principal researcher(s)	THOMPSON & ASSOCIATES LIMITED AND NORECOL ENVIRONMENTAL CONSULTANTS LIMITED
Supervising agency	B.C. ENGINEERING AND INSPECTION BRANCH
Other participating agencies	SEREM INCORPORATED (NOW CHENI GOLD MINES INCORPORATED)
Project location	NORTH CENTRAL B.C.

OBJECTIVES To assist with the development of the Lawyers gold-silver mine in the Toodoggone River area of north central British Columbia by undertaking an engineering and environmental study to determine the optimal design of road access to the Lawyers property.

Development of mine access roads has helped to curtail the high costs of alternate transportation.

ACHIEVEMENTS A ground survey of the route was conducted and designs produced for a 50 kilometre/hour roadway with a 5 metre wide gravel surface. Plans/profiles, quantity estimates, stream crossing and drainage designs and reclamation plans for disturbed areas were prepared. Wildlife studies including a winter reconnaissance wildlife population inventory and fisheries studies were also undertaken. The plans for the selected road route were presented to the British Columbia Mine Development Steering Committee.

IMPACT This project led to a road design that was subsequently constructed with partial funding through a loan from the Province. The road was instrumental in the development of the Lawyers deposit and is also being used by other companies actively exploring/producing in the Toodoggone River gold camp.

OUTPUTS

Thompson & Associates Limited (1985): *Report on Extension of Omineca Mine Access Road.*

Norecol Environmental Consultants Limited (1986): *Wildlife Studies in Vicinity of the Omineca Mine Access Road Extension, Winter 85-86.*

Project name	MASCOT GOLD MINES
MDA expenditures	$11,500 (1986)
Principal researcher(s)	FENCO LAVALIN CORPORATION AND KER, PRIESTMAN & ASSOCIATES LIMITED
Supervising agency	B.C. ENGINEERING AND INSPECTION BRANCH
Other participating agencies	MASCOT GOLD MINES LIMITED
Project location	SOUTH CENTRAL B.C.

OBJECTIVES To assist with the development of the Nickel Plate gold mine project in south central British Columbia by contributing towards the design of the necessary upgrading for the road west of Apex Village Ski Hill Resort to the mine property.

ACHIEVEMENTS A report was produced that looked at alignment improvements and costs to upgrade the existing mine access road to a 10 metre wide surface and a 50 kilometre per hour maximum design speed. A road survey along the existing road and several reconnaissance surveys of possible relocation routes were conducted. The report recommended improvements that included among other things, an increase in the radius of two sharp switchback curves and a widening of two gully curves. Cost estimates for the proposed and alternative alignments were presented.

IMPACT This design study ultimately led to the upgrading of 12 kilometres of mining road access from Apex Village Ski Hill Resort to Mascot Gold Mines Limited mine property (now operated by Corona Corporation).

OUTPUTS

Fenco Lavalin Corporation and Ker, Priestman & Associates (1986): *Report on the Mine Design of the Nickel Plate Access Road.*

Project name	ISKUT ROAD STUDY
MDA expenditures	$50,375 (1989-1990)
Total project cost	Approximately $75,000
Principal researcher(s)	THURBER CONSULTANTS LIMITED
Supervising agency	B.C. ENGINEERING AND INSPECTION AND MINERAL POLICY BRANCHES
Other participating agencies	COMINCO LIMITED, SKYLINE GOLD CORPORATION, SULPHURETS GOLD CORPORATION, ECHO BAY MINES LIMITED, CONSOLIDATED SILVER STANDARD MINES LIMITED, NEWHAWK GOLD MINES LIMITED, PRIME RESOURCES CORPORATION, CALPINE RESOURCES INCORPORATED, PEZGOLD RESOURCE CORPORATION, ADRIAN RESOURCES LIMITED, TICKER TAPE RESOURCES LIMITED, CHERYL RESOURCES INCORPORATED, MAGENTA DEVELOPMENT CORPORATION, LINK RESOURCES INCORPORATED, CREST RESOURCES LIMITED, CORPTECH INDUSTRIES INCORPORATED, EQUITY SILVER MINES LIMITED, HOMESTAKE MINERAL DEVELOPMENT COMPANY AND MINGOLD RESOURCES INCORPORATED
Project location	NORTHWEST B.C.

OBJECTIVES To guide and stimulate resource development in the Iskut River Valley of northwestern British Columbia by identifying an approvable multi-purpose access road corridor to the developing gold mines in the Bronson Creek/ Johnny Mountain area. This project intended to coordinate input by government agencies, potential industrial users of the road and qualified consultants.

ACHIEVEMENTS A report was produced that presented an assessment of six road corridors that could be developed. The study focussed on engineering factors, including feasibility, road alignment and costs, but also addressed environmental considerations in an overview manner. A review of previous engineering and geological reports was presented, supplemented by a detailed terrain analysis of the corridors by aerial photo interpretation. Road alignments were established on 1:10 000 scale topographic maps produced for the study and field checked for engineering aspects by helicopter reconnaissance. Construction and maintenance costs for the road were also estimated. Of the six potential corridors studied, the Iskut Valley route was determined to be preferable for economic, environmental, and regional development reasons. The study indicated that mineral, timber, and recreational values would be better utilized if a road was built into the area.

IMPACT The Iskut River Valley is resource rich but lacks road access. The economic benefits of a road would include more efficient mineral exploration, extraction and mine development, expanded forestry operations, potential new tourism opportunities and expanded markets for businesses in Stewart, Terrace and Smithers. Mining and timber companies have been lobbying the provincial government for permission to build a a road and for financial assistance with the capital cost of construction. This study provided considerable information and led to a subsequent investigation to determine the relative economic advantages of a road.

OUTPUTS

Thurber Consultants Limited (1989): *Iskut Valley Road Option Study*. Report to British Columbia Ministry of Energy, Mines and Petroleum Resources.

Project name	**ISKUT ROAD ECONOMIC ASSESSMENT**
MDA expenditures	**$44,250 (1990)**
Principal researcher(s)	**CLAYTON RESOURCES LIMITED, ROBINSON CONSULTING & ASSOCIATES LIMITED AND WESTERN ECONOMIC CONSULTING LIMITED**
Supervising agency	**B.C. MINERAL POLICY BRANCH**
Project location	**NORTHWEST B.C.**

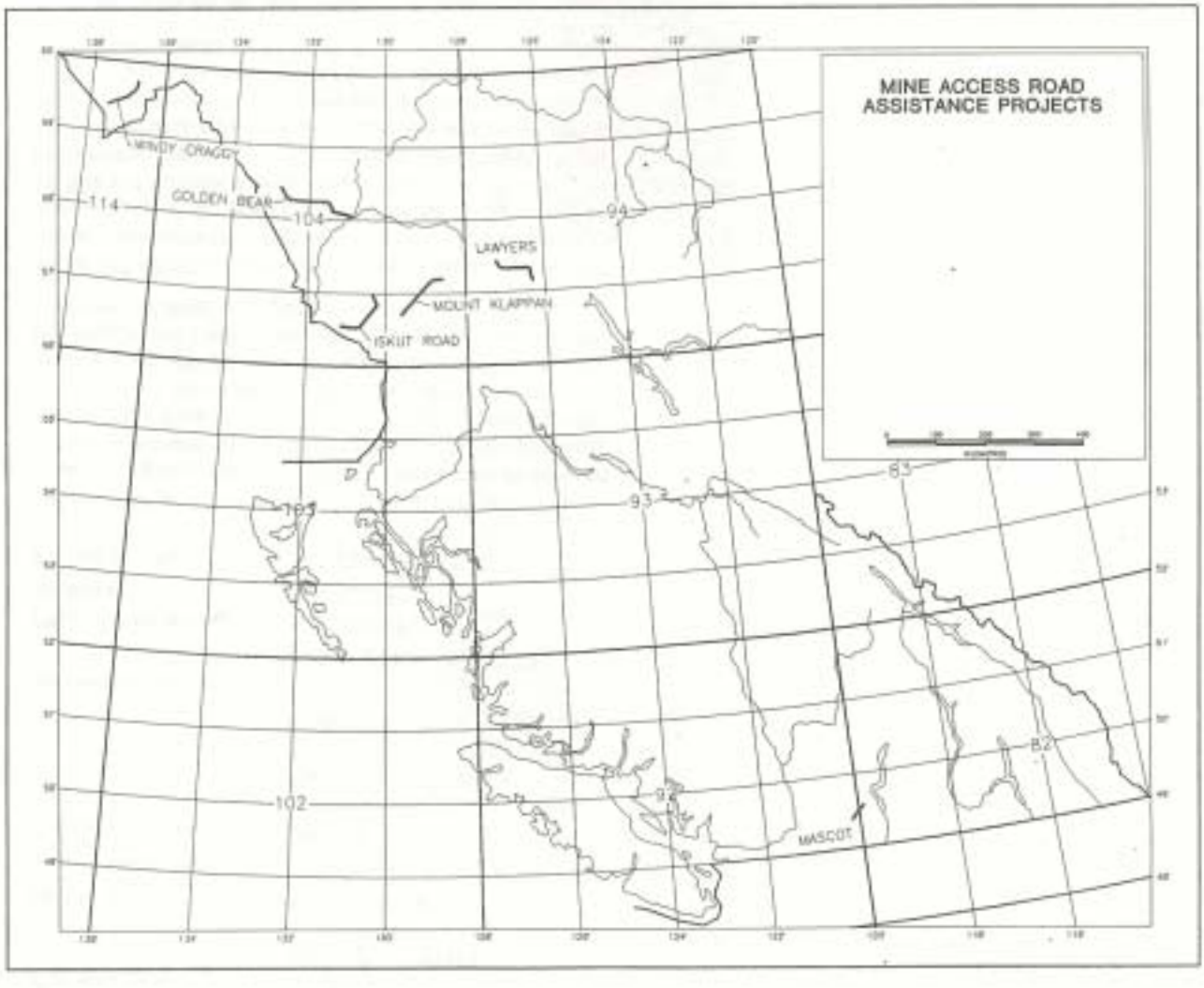
OBJECTIVES To encourage economic development by determining the relative economic advantages of key transportation options to the resource-rich Iskut River Valley, and examining the distribution of these advantages, whether they be for the benefit of the mining companies, the State of Alaska or the Province of British Columbia.

ACHIEVEMENTS A benefit-cost analysis of road access alternatives was conducted, with a central focus on nine mining properties as potential beneficiaries. The two main access options considered were through the Iskut Valley to connect with the existing Highway #37 in British Columbia, and from the Iskut Valley through the Alaska Panhandle to tidewater at the head of the Bradfield Canal in Alaska. The report concludes that the Iskut Valley road is an economically viable project and would generate positive net benefits over a fairly broad range of assumptions. The Bradfield route, on the other hand, was determined not to be economically viable. With construction of the Iskut Valley Road, benefits were found to accrue not only to the mining industry, but also to the forest industry and B.C. Hydro.

IMPACT The positive economic benefits and regional economic impacts that were identified with the road have made its construction a priority of the government.

OUTPUTS

Clayton Resources Limited, Robinson Consulting & Associates Limited & Western Economic Consulting Limited (1989): *A Benefit Cost Analysis of Transportation Alternatives for the Iskut Valley.*



Project name	**WINDY CRAGGY ROAD STUDY**
MDA expenditures	**$50,000 (1990)**
Total project cost	**Approximately $98,000**
Principal researcher(s)	**DELCAN CORPORATION, NORECOL ENVIRONMENTAL CONSULTANTS LIMITED AND THURBER CONSULTANTS LIMITED**
Supervising agency	**B.C. ENGINEERING AND INSPECTION BRANCH**
Other participating agencies	**GEDDES RESOURCES LIMITED**
Project location	**NORTHWEST B.C.**

OBJECTIVES To further the development of the Windy Craggy copper, gold, silver, cobalt deposit in northwestern British Columbia by conducting a road access planning study of the proposed route to the mine site through the Tatshenshini River basin. The study intended to focus primarily on bridge location and design, visual impacts of the bridge and road within the Tatshenshini valley and potential wilderness impacts.

ACHIEVEMENTS A report was produced that presented design criteria for the proposed access road and a preliminary layout of the horizontal and vertical alignment on 1:5 000 and 1:10 000 topographical mapping. Preliminary bridge crossings and culvert locations was identified. An assessment of environmental, wilderness and geotechnical concerns were presented. A preliminary description of the route alignment and provisions for a preliminary construction schedule were also included.

IMPACT This project was designed to help the company find a route that would minimize the visual and wilderness impacts of road access to the Windy Craggy mine site. Studies are still ongoing.

OUTPUTS

Delcan Corporation, Norecol Environmental Consultants Limited, & Thurber Consultants Limited (1990): *Windy Craggy Project: Stage I Environmental and Socioeconomic Impact Assessment, Volume III, Access Road Report*. Submitted by Geddes Resources Limited.

PROGRAM III

3. Management, Public Information and Evaluation

The purpose of this program was to provide funds for management, supervision, public information and support services. Total expenditures of approximately $526,000 were spent to acquire the services of a contracted MDA administrator/manager, provide for office and travel expenditures, conduct an annual independent financial audit, fund an independent evaluation program, and undertake an information program to apprise both the public and the minerals industry of the status and results of MDA activities.

Project name	PUBLIC INFORMATION AND MDA PROMOTION
MDA expenditures	$33,229 (1986-1990) $40,000 (Budgeted, 1991)
Principal researcher(s)	G. MCKILLOP
Supervising agency	MDA COMMUNICATIONS SUBCOMMITTEE
Project location	VICTORIA

OBJECTIVES To carry out public information activities to make the public and the mineral industry aware of the programs and results of the Canada/British Columbia Mineral Development Agreement and to describe future plans. The emphasis for the general public was to increase public understanding of the province's mineral resources and government's role in promoting and managing these resources. Activities directed towards the mineral industry were primarily intended to facilitate the dissemination of geological, technical and marketing information generated by MDA activities.

MDA geological survey data was shared with the public through numerous talks and poster displays.

ACHIEVEMENTS A variety of promotional activities were employed. These included: newsletters, brochures, displays, annual reports and the project summary report. A series of newspaper articles were produced and distributed to regional newspapers for publication. The articles documented MDA funded activities of regional significance, in particular, those research projects designed to minimize the impact of mining on the environment.

IMPACT Interest in the project displays was very high. Each issue of the newsletter was followed by a wave of enquiries regarding MDA programs and specific projects and by an increase in sales of MDA outputs. The activities undertaken to promote the MDA successfully heightened industry and public awareness of the program.

OUTPUTS

McKillop, G.R., Smyth, W.R. and McRae, B. (1985): The Canada/British Columbia Mineral Development Agreement, *British Columbia Ministry of Energy, Mines and Petroleum Resources, Geological Fieldwork*, 1985, Paper 1986-1, pages 9-10.

Canada/British Columbia Mineral Development Agreement Annual Report, 1985, 1986, 1987, 1988, 1989, 1990.

Canada/British Columbia Mineral Development Agreement Report, September 1986, January 1988, July 1988, August 1989, April 1990.

BC MDA Update, May 1986, July 1987.

Canada/ British Columbia Mineral Development Project Summary Report, 1990.

A series of newspaper articles were produced and distributed to regional newspapers throughout the province for publication.

Brochures

Ministry of Energy, Mines and Petroleum Resources (1989): *Mining in British Columbia: The Federal-Provincial Program.*

Canada/British Columbia Mineral Development Agreement: An Economic and Regional Development Agreement Program.

Talks

McKillop, G.R. (1989): "Canada/British Columbia MDA." A presentation made at the Annual Cordilleran Roundup in Vancouver, British Columbia.

McKillop, G.R. (1989): "Canada/British Columbia MDA". A presentation made at the Preview Seminar for the 1989 Regional Geochemical Survey Release in Campbell River, British Columbia.

Presentations were made at the following:

- British Columbia Chamber of Commerce Mining Committee, Vancouver, British Columbia, 1986.
- British Columbia Acid Mine Drainage Task Force, Vancouver, British Columbia, 1987.
- Thompson Okanagan Development Region Mining Task Force, Kelowna, British Columbia, 1989.
- Kootenay Development Region Natural Resources Task Force, Cranbrook, British Columbia, 1989.
- Northeast Development Region Natural Resources Task Force, Dawson Creek, 1989.

Displays

Annual displays were set up at the following:

- Prospectors and Developers Convention in Toronto, Ontario, 1986, 1987, 1988, 1989, 1990.
- Annual Cordilleran Roundup in Vancouver, British Columbia, 1986, 1987, 1988, 1989, 1990.

One-time displays

- Vancouver Courthouse Complex, Vancouver, British Columbia, 1988.
- Mine Reclamation Symposium, Vernon, British Columbia, 1988.
- Union of B.C. Municipalities in Penticton, British Columbia, 1989.
- AMD Short Course, Vancouver, British Columbia, 1989.
- Mining Week, Mining Association of British Columbia, Vancouver, British Columbia, 1990.

Project name	EVALUATION
MDA expenditures	$56,533 (1988-1990) $15,000 (1991)
Principal researcher(s)	DON FERRANCE AND ASSOCIATES
Supervising agency	MDA EVALUATION SUB-COMMITTEE
Project location	VANCOUVER

OBJECTIVES To carry out an independent evaluation and assessment of the effectiveness and impacts of the programs funded under the Canada/British Columbia Mineral Development Agreement.

ACHIEVEMENTS A consultant was hired to undertake a review of the various draft evaluation frameworks prepared by the Management Committee and others, recommend a workable approach and then use this method to undertake the evaluation. A preliminary evaluation was carried out in 1989-90 and a final evaluation in 1990-91. The preliminary evaluation involved 120 personal or telephone interviews with people directly involved with MDA programs and 226 mailed questionnaires with representatives of the exploration and mining industry and government. Some of the conclusions of the preliminary evaluation were: MDA funded geological survey projects have had a substantial impact; economic data development projects

have assisted the public sector in developing policies and making decisions; market studies have assisted industry in identifying opportunities and preparing development strategies for industrial minerals; through MDA funding, significant progress has been made with respect to understanding and developing possible solutions to the acid mine drainage issue; the primary impact of the environment-related projects has been on the regulatory environment; and the FAMD projects have served to increase government involvement in the planning of several controversial road developments into previously inaccessible wilderness areas. Recommendations to be considered in the planning of a subsequent MDA included the following: increased funding; a reallocation of program funding; greater industry input into design of programs and selection of projects. The overall lack of awareness by the public of the MDA program was cited and the rationale for a strong information program explained.

IMPACT The evaluation highlighted the impacts of the MDA and outlined the levels of awareness and areas of concern of many of the diverse sectors of the province's mining industry.

OUTPUTS

Don Ferrance & Associates Limited (in preparation): Canada - British Columbia Subsidiary Agreement on Mineral Development: Final Evaluation. Main Report and Appendices.

Don Ferrance & Associates Limited (1990): *Canada - British Columbia Subsidiary Agreement on Mineral Development: Detailed Interim Evaluation*. Main Report and Appendix to Main Report.

APPENDIX A

MDA Financial Summary

MDA FINANCIAL SUMMARY

Project Name	1985/86	1986/87	1987/88	1988/89	1989/90	Budget – 1990/91	Total
PROGRAM 1 - PROMOTION OF B.C. MINERAL POTENTIAL							
GEOLOGICAL SURVEYS							
Geochemistry							
Regional Geochemical Surveys	$127,539	$ 160,360	$ 197,382	$ 198,352	$ 183,906	$128,000	$ 995,539
Analysis of Archived RGS				49,998			$ 49,998
Geochemical Interpretation	27,026	75,477					$ 102,503
	$154,565	$ 235,837	$ 197,382	$ 248,350	$ 183,906	$128,000	$ 1,148,040
1:50 000 Mapping							
Gataga	$ 29,806	$ 19,512					$ 49,318
Sicker		165,763	$ 133,245	$ 133,260	$ 23,142		$ 455,410
Taseko-Bridge River		184,210	156,181	147,541	149,183	$ 46,500	$ 683,615
Whitesail		149,384	140,215	111,938	76,707	40,000	$ 518,244
Midway-Cassiar		190,725	153,217	162,682	79,868	3,500	$ 589,992
Bullmoose		56,709					$ 56,709
Technical Editor and Publications Input		12,744	51,557	50,535	45,982	30,000	$ 190,818
Support Services and Provincial Overhead		49,486	46,622	41,805	26,097	10,000	$ 174,010
	$ 29,806	$ 828,533	$ 681,037	$ 647,761	$ 400,979	$130,000	$ 2,718,116

MDA FINANCIAL SUMMARY – *Continued*

Project Name	1985/86	1986/87	1987/88	1988/89	1989/90	Budget – 1990/91	Total
Metallogenic Mapping							
Coal							
Flathead Ridge	$ 1,381						$ 1,381
Coal Petrology	4,000						$ 4,000
Elk Valley	10,075	$ 9,439					$ 19,514
Gething Formation		9,974	$ 11,230				$ 21,204
Carbon Creek		3,045					$ 3,045
Gold							
Hedley Gold		89,398					$ 89,398
Gold Skarns			61,499				$ 61,499
Northwest B.C. Gold Studies	13,485						$ 13,485
Northwest B.C Studies		12,207					$ 12,207
Southern B.C. Gold Studies		29,797					$ 29,797
Quesnel Gold		94,377					$ 94,377
Vancouver Island, Island Metallogeny	9,392	4,078					$ 13,470
Mount Washington Minerals				$ 10,000			$ 10,000
Flathead Syenite Intrusions				9,857			$ 9,857
Other							
Alice Arm	60,042						$ 60,042
Barriere	32,663						$ 32,663
Chilko Lake	46,188	56,817					$ 103,005
Wapiti Lake	6,230						$ 6,230
Mafic & Ultramafic Rocks			129,728	130,599	$ 157,461	$ 40,000	$ 457,788
Babine Range		27,655					$ 27,655
Zircon Separation, Microfossil Separation, Geochemical Research, Light Stable Isotopes	12,705						$ 12,705
Support Services and Provincial Overhead	5,497		49,533	100,000	89,000		$ 244,030
UBC Mineral Research Support		46,900	60,000	50,000	60,008		$ 216,908
	$201,658	$ 383,687	$ 311,990	$ 300,456	$ 306,469	$ 40,000	$ 1,544,260

MDA FINANCIAL SUMMARY – *Continued*

Project Name	1985/86	1986/87	1987/88	1988/89	1989/90	Budget – 1990/91	Total
Industrial Minerals							
Dimension Stone	$ 18,576	$ 7,018					$ 25,594
Carbonatites and Kimberlites	8,691	33,913	$ 30,427				$ 73,031
Olivine		8,099	1,500				$ 9,599
Tertiary Basins		44,360	61,045	$ 86,881	$ 26,202		$ 218,488
Phosphate		68,903	81,870	1,606			$ 152,379
Aley Carbonatite		5,100					$ 5,100
Kyanite/Garnet			17,278				$ 17,278
Peat Inventory			12,641				$ 12,641
Talc Assessment			10,417				$ 10,417
Flourospar Potential				51,310			$ 51,310
Limestone and Dolomite					23,456		$ 23,456
Barite					28,269		$ 28,269
	$ 27,267	$ 167,393	$ 215,178	$ 139,797	$ 77,927		$ 627,562
Geophysics							
Aeromagnetic Surveys		$ 250,000	$ 308,579	$ 66,421			$ 625,000
GEOSCIENCE DATA SYSTEMS							
MINFILE	$ 24,633	$ 136,502	$ 148,867	$ 92,026		$ 2,747	$ 404,775
Computer File - Radio metric dates	3,625						$ 3,625
Lithgeochemistry		9,600					$ 9,600
	$ 28,258	$ 146,102	$ 148,867	$ 92,026		$ 2,747	$ 418,000

MDA FINANCIAL SUMMARY – *Continued*

Project Name	1985/86	1986/87	1987/88	1988/89	1989/90	Budget – 1990/91	Total
MARKET, TECHNICAL AND FEASIBILITY STUDIES							
Mineral Economic Data Development							
Mine Profile System	$ 6,000	$ 14,133	$ 52,619				$ 72,752
Comparative Tax Study	2,680						$ 2,680
Structural Change to Mine Industry				$ 10,000			$ 10,000
Public Attitude Survey				10,000			$ 10,000
Industrial Minerals Milling				5,000			$ 5,000
Native Participation in Mining					$ 8,125		$ 8,125
B.C. Reclamation Fund Study					19,500		$ 19,500
	$ 8,680	$ 14,133	$ 52,619	$ 25,000	$ 27,625		$ 128,057
Mineral Opportunities Market Studies							
Mohawk Jade Tile Production		$ 25,000					$ 25,000
Industrial Mineral Market Studies		4,039					$ 4,039
Gypsum Market Study		15,000					$ 15,000
Feldspar Market Study			$ 33,347	$ 1,758			$ 35,105
Market Study: Modified Talc				1,500	$ 18		$ 1,518
Dimension Stone Market Study				15,143			$ 15,143
Barium Carbonate Market Study					10,000		$ 10,000
Garnet Market Study					11,195		$ 11,195
Strategic Plan, Industrial Minerals					9,222		$ 9,222
Industrial Minerals Transportation Study					20,000		$ 20,000
Mineral Opportunities Technology Development							
Mine Dump Resloping	18,000						$ 18,000
Portable Modular Mills	19,935						$ 19,935
Heap Leach Pre-Feasibility		3,000					$ 3,000
Rock Drains Symposium		10,000					$ 10,000
Video Graphics Development			3,000				$ 3,000
Mine Research and Development			7,016				$ 7,016
Fresh Air Base			10,000				$ 10,000
Extended Work Hours					4,988		$ 4,988
Westar Spiral Test		10,000					$ 10,000

MDA FINANCIAL SUMMARY – *Continued*

Project Name	1985/86	1986/87	1987/88	1988/89	1989/90	Budget – 1990/91	Total
Coal Waste Dump Stability		$ 30,000					$ 30,000
Coal Fines Agglomeration			$ 25,000				$ 25,000
Coal Tailings Agglomeration			26,500				$ 26,500
Quick Coal Washability Test					$ 5,798		$ 5,798
Foothills Surface Geophysics					30,000		$ 30,000
Westmin AMD and Waste Rock Treatment			25,000	$ 29,600	29,990	$ 10,000	$ 94,590
Kutcho Creek AMD - Blending and Segregation				25,000	30,000	10,000	$ 65,000
Waste Dump Hydrogeochemistry					25,000		$ 25,000
Cyanide in Groundwater					16,000		$ 16,000
Fraser River Gravel Study					5,000		$ 5,000
	$37,935	$ 97,039	$ 129,863	$ 73,001	$ 197,211	$ 20,000	$ 555,049
Mineral Supply Forecasting							
Commodity Research Unit Reports		$ 20,000	$ 6,500	$ 12,000			$ 38,500
R & D Fund							
Electric Shock Hazard Study				$ 32,036			$ 32,036
Exploration Safety Seminar					$ 1,000		$ 1,000
Mount Washington Instrumentation and Data Summary				8,170	5,292		$ 13,462
AMD Technology Guide				70,163	8,020		$ 78,183
Underwater Disposal				49,984	49,830	$ 10,000	$ 109,814
Prediction: Open Pits					20,850		$ 20,850
Gibraltar AMD Model					15,140	10,000	$ 25,140
Constructed Wetland Bell Mine					22,464	10,000	$ 32,464
Optimum Sampling Frequency					25,697		$ 25,697
Biological Monitoring of AMD					20,319		$ 20,319
Aquatic Invertebrates Monitoring					40,000	40,000	$ 80,000
AMD Sediment Monitoring					4,998		$ 4,998
Diagenesis in Aquatic Tailings					4,000		$ 4,000
Ion Speciation Model						11,000	$ 11,000
Report Publication						25,000	$ 25,000
				$ 160,353	$ 217,610	$106,000	$ 483,963

MDA FINANCIAL SUMMARY – *Concluded*

Project Name	1985/86	1986/87	1987/88	1988/89	1989/90	Budget – 1990/91	Total
PROGRAM 2 - FINANCIAL ASSISTANCE FOR MINE DEVELOPMENT							
Mt. Klappan - Pre-Engineering Study	$ 12,000						$ 12,000
Mt. Klappan - Detailed Study	167,881	$ 198,073	$ 229,109				$ 595,063
Anthracite Market Study		22,997					$ 22,997
Serem/Lawyers	111,261	5,501					$ 116,762
Mascot Gold Mines	11,500						$ 11,500
Golden Bear Transportation Option I			6,250				$ 6,250
Golden Bear Access Road			173,735				$ 173,735
Golden Bear Transportation Option II			22,499				$ 22,499
Iskut Road Study				$ 49,998	$ 377		$ 50,375
Iskut Road Economic Assessment					44,250		$ 44,250
Windy Craggy Road Study					50,000		$ 50,000
	$302,642	$ 226,571	$ 431,593	$ 49,998	$ 94,627		$ 1,105,431
PROGRAM 3 - MANAGEMENT, PUBLIC INFORMATION AND EVALUATION							
Management and Audit	$ 19,692	$ 62,251	$ 63,668	$ 66,777	$ 84,327	$ 85,000	$ 381,715
Public Information and Promotion	12,176	5,218	4,311	5,812	5,712	40,000	$ 73,229
Evaluation			6,833		49,700	15,000	$ 71,533
	$ 31,868	$ 67,469	$ 74,812	$ 72,589	$ 139,739	$140,000	$ 526,477
TOTALS	$822,679	$2,436,764	$2,558,420	$1,887,752	$1,646,093	$566,747	$ 9,918,455

APPENDIX B

Reports Available

Publications of the British Columbia Geological Survey Branch are available from:

B.C. AND YUKON CHAMBER OF MINES
840 West Hastings Street
Vancouver, British Columbia, V6C 1C8
(604) 681-5328

OR

CROWN PUBLICATIONS INC.
546 Yates Street
Victoria, British Columbia, V8V 1K8
(604) 386-4636

The reports listed below are available from:

ISLAND BLUE PRINT CO. LTD.
905 Fort Street
Victoria, British Columbia, V8V 3K3
(604) 385-9786

Resource Assessment for Coastal and Western British Columbia and the Development of a Portable Modular Mill Design.

A Preliminary Evaluation of Heap Leaching, Energex Minerals Toodoggone Project.

Market Study of B.C.'s Gypsum in the Pacific Rim Area of North America.

Regional Study of Coal Mine Waste Dumps in B.C. (color version of the above report).

A Study of Markets for B.C.'s Nepheline Syenite and Feldspathic Minerals.

The Custom Milling of Industrial Minerals in B.C.: a Study of Commercial Feasibility.

British Columbia Dimension Stone Market Study.

A Study of Mining Shock Hazards.

Transportation Cost Study for Industrial Mineral Deposits.

The report listed below is available from:

BITECH PUBLISHERS LTD.
903 - 580 Hornby Street
Vancouver, British Columbia, V6C 3B6
(604) 669-4280

International Symposium on Flow Through Rock Drains (1987), by the B.C. Technical and Research Committee on Reclamation.

The report listed below is available from:

CROWN PUBLICATIONS INC.
546 Yates Street
Victoria, British Columbia, V8V 1K8
(604) 386-4636

Acid Rock Drainage Technical Guide (1989) Volume I, (1990) Volume II, by Steffen Robertson and Kirsten (B.C.) Inc., Norecol Environmental Consultants, and Gormely Process Engineering.

For further information contact:

Mr. Greg McKillop
Manager
Program Development and Statistics
Ministry of Energy, Mines and Petroleum Resources
Parliament Buildings
Victoria, British Columbia
V8V 1X4
(604) 356-2854

Mineral Development Agreement

Canada–British Columbia 1985–1990

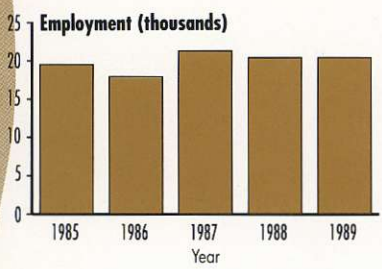
MDA

SUSTAINABLE MINERAL DEVELOPMENT

Canada

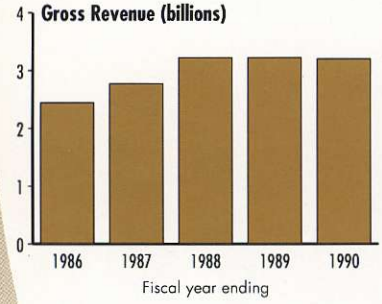
BC

Mining in British Columbia



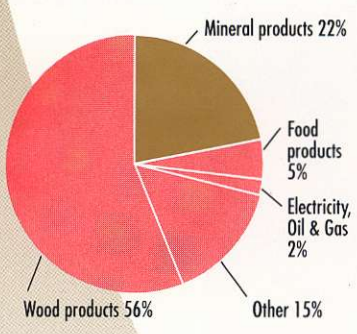
Over 20 000 people are directly employed in B.C.'s mining industry.

Another 35 000 are indirectly employed in supply, transportation and service industries.



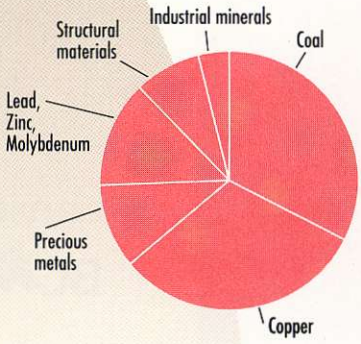
Over $3 billion in revenue annually for the B.C. economy.

Many communities throughout B.C. depend on the mining industry. For instance, in 1989 revenues of $1.3 billion were generated in the Kootenay region.



Mineral products are 22 per cent of B.C.'s total exports.

Roberts Bank, one of the world's leading coal ports, ships over 17 million tonnes per year.



Coal and copper are B.C.'s most important minerals. B.C. is the world's leading exporter of copper concentrate.

Recent technological breakthroughs in the fields of medicine, aerospace engineering, electronics, computers and superconductors are now also creating opportunities for "high technology" metals in B.C.

The Mineral Development Agreement — MDA

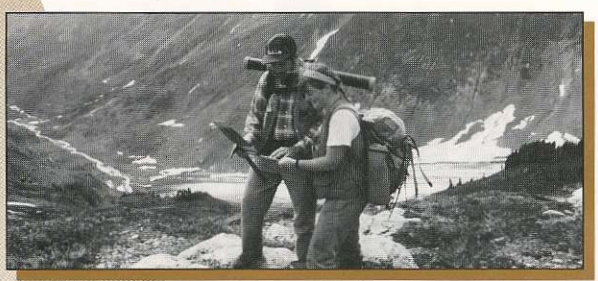
- Funding of this $10 million program was cost-shared equally between the federal and provincial governments through the five-year agreement, April 1, 1985 to March 31, 1990.
- MDA co-ordinated federal and provincial efforts to strengthen and diversify B.C.'s mineral industry.
- The Canada/British Columbia Mineral Development Agreement (MDA) was one of eight subsidiary agreements developed under the Canada/British Columbia Economic and Regional Development Agreement (ERDA).

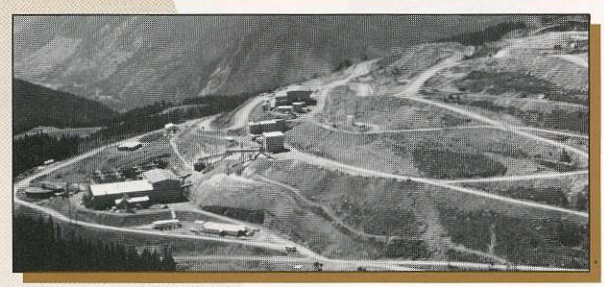
Five Years of Achievement

- 25 to 30 per cent of exploration companies surveyed stated that the MDA had a significant impact on their exploration decisions.
- 75 per cent of these companies found that MDA projects improved their cost-effectiveness.
- At least $5.6 million in new exploration investments resulted from the MDA.

Strengthening and Diversifying B.C.'s Mining Industry

- Over 60 geological survey projects added new understanding of the province's mineral potential. This led to increased exploration activity and better targeting of exploration and development programs.
- Significant mineral occurrences have been discovered and information made available to the mining public. The opportunities presented by industrial minerals, such as talc, gypsum and feldspar, are now attracting industry's imagination and involvement.
- Marketing studies under the MDA aimed to diversify the industry and find local processing and export opportunities for B.C.'s jade, gypsum, feldspar, talc, dimension stone, barium carbonate and garnet.
- Feasibility studies were targeted at improving health, safety and efficiency, cutting waste, reducing environmental impacts and enhancing recovery of coal and metals. The studies were cost-shared with industry, who have been quick to adopt the new techniques.
- Economic studies have guided government policy and decision-making.
- Support for university research programs increased knowledge of our bountiful mineral resources.
- Information about the social responsibilities of mining in our province such as: mine closure, regional impacts, native participation, equitable taxation and financial incentives for sound environmentally-aware reclamation have also been promoted.





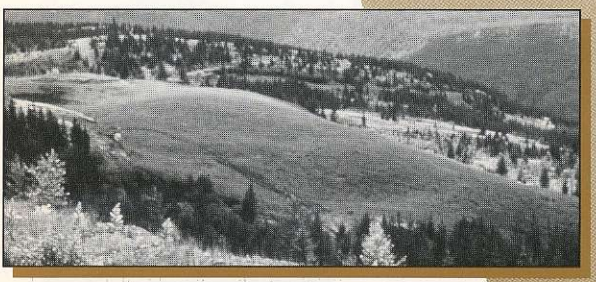
A Cleaner and Safer Environment

The environmental challenges posed by mining received particular attention:

- Studies of cyanide management, coal mine waste dump stability and rock drains produced far-reaching impacts. High-profile joint government/industry initiatives to resolve critical acid mine drainage issues received global attention and recognition. A team of consultants prepared a state-of-the-art manual addressing acid rock drainage.
- Long-term reclamation strategies to protect environmentally sensitive areas were examined.

Mining is B.C.'s safest heavy industry. MDA projects help to keep it that way. Several projects looked at ways to improve worker safety:

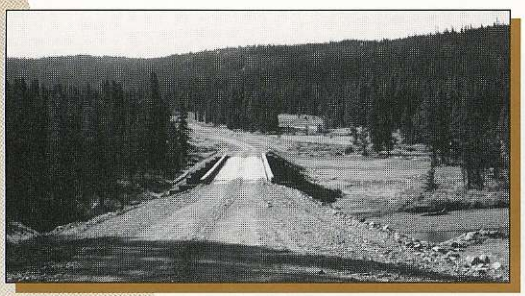
- Developing a portable safety chamber for underground mine safety.
- Pioneering study underway on health and safety aspects of extended underground shift work.
- Auditing electrical standards for open pit mines. This study is leading to new, higher safety standards.
- MDA/industry joint initiative for sponsoring safety training for mineral exploration.

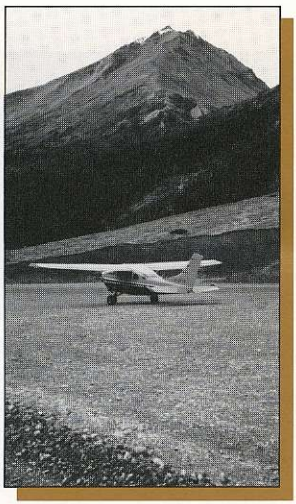


Financial Assistance for Mine Development

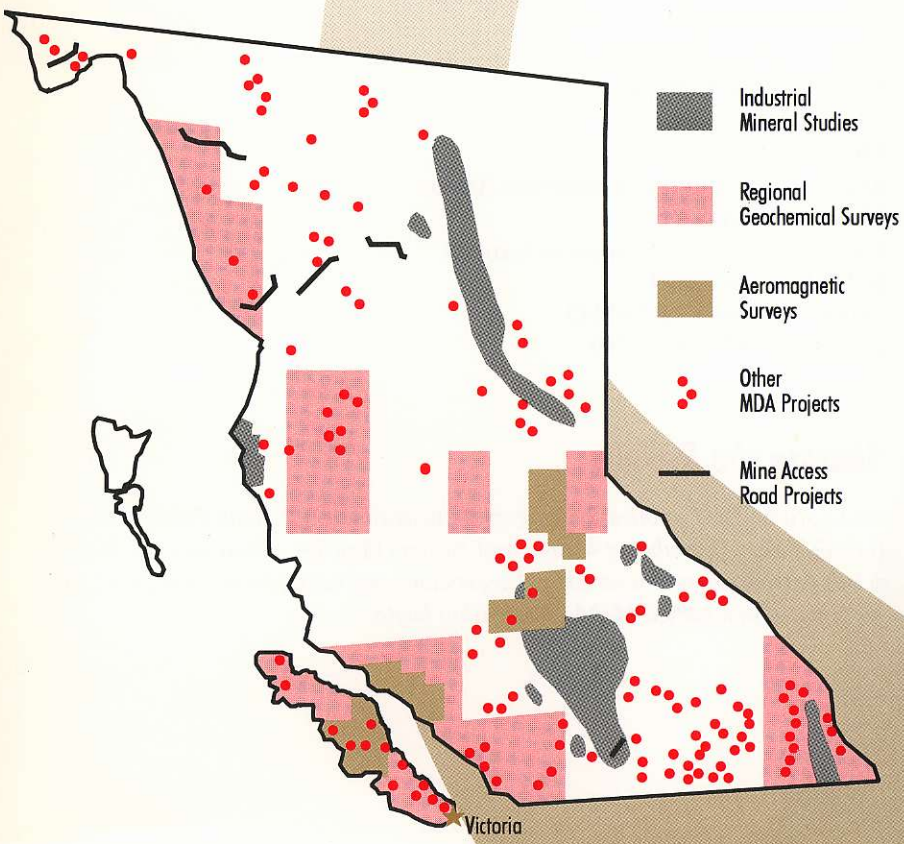
Infrastructure for six potential mines helped bring some of B.C.'s more remote ore bodies into production. These studies integrated proven environmental protection measures into the technical design and location of mine access roads. As a result, regional development opportunities have been enhanced and new jobs have been created:

- Nickel Plate gold/silver mine — created 173 new jobs.
- Lawyers gold/silver mine — produced $30 million of gold and silver in 1990.
- Golden Bear gold/silver mine — resolved environmental problems, preserved fish and wildlife, and generated much needed employment for local residents.
- Iskut River road — currently under review to access the Johnny Mountain, Snip and Eskay Creek precious metal properties.
- Windy Craggy copper/cobalt/gold/silver project — a comprehensive road study was undertaken and the new mine proposal is under assessment through the Mine Development Review Process.
- Mount Klappan coal project — road studies were completed for this property.





MDA Projects in British Columbia



The Mineral Development Agreement

For further information contact:

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Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario K1S 5H3
Telephone (613) 995-6760

Sharing the Results

MDA studies and publications are publicly available at Crown Publications, B.C. & Yukon Chamber of Mines, and various libraries. There has also been active participation in a number of workshops and conferences throughout the province with a staffed MDA information booth.

Canada BC

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