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GEOLOGICAL SURVEY OF CANADA

The Geological Survey of Canada (GSC), established in 1842, is Canada's national geoscience agency, with 550 employees working at six locations across Canada (addresses on back cover).

GSC's mission is to provide Canada with a comprehensive geoscience knowledge base contributing to economic growth, sustainable development, health and safety, and environmental protection.

The GSC fulfills this mission by:

- mapping and interpreting the regional geological and tectonic framework of Canada's landmass and offshore
- describing and interpreting the nature, quantity, distribution and formation of Canada's mineral and energy resources
- assessing and monitoring the impact of climate change on Canada's landmass and offshore, and developing adaptation strategies to minimize the impacts
- evaluating hazards associated with earthquakes, volcanoes, floods, landslides and metals in the environment, and developing methods for their mitigation
- maintaining national geoscience databases (including archives and reference collections), and making this information readily available.

The GSC works in close collaboration with other government departments in Canada at all levels, with Canadian industry and universities, and with other countries and international organizations.

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GSC founder named most influential Canadian scientist in history

MACLEAN'S MAGAZINE, IN THEIR CANADA DAY EDITION listing the 100 most important Canadians in history, ranked

Sir William Logan first among scientists and sixth overall. His accomplishments and achievements were described in a two-page spread. Media interest in the list was strong, and Logan was discussed on many national shows. This was a particularly fitting and timely tribute, as April 20, 1998 marked the 200th anniversary of Logan's birth.

Visit GSC's Logan website at <http://www.nrcan.gc.ca/gsc/logan/>.



SIR WILLIAM LOGAN "... WAS ONE OF THE COUNTRY'S GREATEST SCIENTISTS AND A MAN WHOSE IMPRINT REMAINS ON THE LAND."

Maclean's, July 1998

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MORE THAN A CENTURY AND A HALF AGO, the pioneering scientists of the Geological Survey of Canada (GSC) were among the first to chart the frontiers of Canada. In 1842, they set out to map and evaluate the

mineral riches of a vast wilderness. They uncovered valuable information about natural resources, topography, geology, flora, fauna and the people who inhabited the land.

That pioneering spirit and quest for knowledge is still the foundation for GSC's work. Its role is unique in the exploration and economic development of Canada. The GSC is also an internationally respected leader in the science and research that helps us understand Canada's landmass.

GSC's innovative thinking has been instrumental in developing technologies that allow us to "see" into the depths of the Earth and the oceans. Because of the efforts of GSC researchers, Canadians are better prepared for natural disasters, such as earthquakes, landslides and volcanoes, and urban planning and building practices have been improved. GSC's work is also providing us with the tools we need to tackle environmental concerns and to address pressing environmental issues such as climate change.

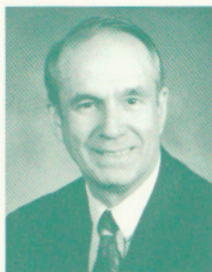
GSC's vital geoscientific expertise helps Canadians make wise and effective decisions about sustainable development, which is the key to achieving both our economic and environmental goals. If Canada is to become the world's smartest natural resources developer, user and exporter in the next millennium – the most high-tech, the most environmentally friendly and socially responsible, the most productive and competitive – GSC capabilities, experience and leadership will be increasingly important. And the GSC is transforming the critical challenges facing Canada's natural resources sector into opportunities for growth, jobs and global leadership.

The pages that follow highlight the latest achievements of the men and women of the GSC and the milestones they have reached. With its history of discovery and its philosophy of effectively using cutting-edge and innovative technology, I am confident that the GSC will continue building on its tradition of excellence into the 21st century. I am equally confident that it will continue to serve Canadians well and help to create a better future for our country.

A handwritten signature in black ink, which appears to read "Ralph Goodale".

THE HONOURABLE RALPH GOODALE
Minister of Natural Resources Canada

INTRODUCTION



IT IS A GREAT PLEASURE TO INTRODUCE another Annual Review of the achievements of the Geological Survey of Canada. As in past years the GSC has a number of major success stories of which I am proud. Many of these

show the considerable benefits that come from addressing Canada's geoscience needs in collaboration with the provinces, territories, universities and industry.

One of the highlights of the past year was an independent review that showed that the joint GSC-New Brunswick \$6.5M Bathurst EXTECH project will stimulate incremental expenditures by industry of between \$24M and \$45M. By the end of the project the Bathurst Mining Camp will have one of the most comprehensive public geoscience databases in the world. Also in the field of mineral exploration, work by the GSC in collaboration with Manitoba, Falconbridge and INCO has triggered new exploration permitting of over 50,000 hectares in the Thompson Nickel Belt.

One of the strengths of the GSC is the range of expertise and knowledge that it can provide to its clients. As an example, this year has seen an expansion of its work in hydrogeology and groundwater. The successful partnership with local communities created through the Oak Ridges Moraine aquifer mapping project north of Toronto is being repeated in new projects in the Prairies and around Winnipeg, Montreal and Québec City.

Direct outreach to the public, to develop an understanding of the role of earth processes and how they affect our daily lives, also scored a continued success with the Geoscape and GeoMap Vancouver initiatives. These colourful posters with accompanying online materials are leading to collaborative community Geoscapes for nine other areas and cities across Canada.

Finally I want to highlight the role of the GSC in the creation of the Canadian Geoscience Knowledge Network. This partnership with provincial and territorial geoscience agencies will put geoscience knowledge about Canada's landmass and offshore online to the world. In 1998-1999, GSC's component of the Network, ResSources GSC, supported 14 diverse demonstration projects including digital libraries, map databases and a virtual classroom resource centre.

I have mentioned just a few of this year's major successes. I encourage you to read this Annual Review and, if any item is of particular interest, to contact the GSC through the offices listed on the back cover or go to the GSC Website for more information. Making our knowledge available to you is our primary goal.

A handwritten signature in black ink, appearing to read 'M. Denis Everell', written in a cursive style.

MARC DENIS EVERELL

Assistant Deputy Minister, Earth Sciences

NUNAVUT

BUILDING THE GEOSCIENCE INFRASTRUCTURE

ON APRIL 1, 1999, CANADA CELEBRATED THE CREATION OF NUNAVUT. BEHIND THE SCENES, AN IMMENSE EFFORT HAS BEEN DEVOTED TO BUILDING THE INFRASTRUCTURE NEEDED TO GOVERN THIS VAST NEW TERRITORY AND MANAGE ITS RICH RESOURCES. THE GSC IS PROUD TO HAVE BEEN PART OF THIS EFFORT, WORKING CLOSELY WITH NUNAVUT OFFICIALS, REPRESENTATIVES OF THE DEPARTMENT OF INDIAN AND NORTHERN AFFAIRS (DIAND), AND NUNAVUT TUNNGAVIK INC., TO PUT IN PLACE THE CANADA-NUNAVUT GEOSCIENCE OFFICE.

THE GSC HAS A LONG TRADITION OF STUDYING CANADA'S NORTH — MAPPING THE GEOLOGY OF THE LAND AND OFFSHORE, EVALUATING THE RESOURCE POTENTIAL, AND EXAMINING THE ENVIRONMENT. GSC'S ONGOING RESEARCH, CARRIED OUT IN CONJUNCTION WITH OTHER GOVERNMENT AGENCIES, UNIVERSITIES AND PRIVATE SECTOR PARTNERS, HELPS DIRECT THE EFFORTS OF EXPLORATION COMPANIES AND PROVIDES THE INFORMATION NECESSARY FOR SUSTAINABLE DEVELOPMENT OF THE SENSITIVE NORTHERN ENVIRONMENT.

FRAMEWORK FOR GEOSCIENCE COOPERATION

Successful negotiations to develop the framework for Nunavut geoscience cooperation were carried out by officials from GNWT-Nunavut, DIAND, GSC and Nunavut Tunngavik Inc. Planning focused on establishing a Canada-Nunavut Geoscience Office and crafting the agreement to govern coordinated geoscience program delivery. Guiding principles are firmly grounded on respect for Nunavut's land claim agreement and language policy. The Nunavut Geoscience Accord should be ready for signing in late 1999.

THE CANADA-NUNAVUT GEOSCIENCE OFFICE

The Canada-Nunavut Geoscience Office, a partnership initiative co-managed by GSC, the Nunavut Department of Sustainable Development and DIAND, is scheduled to open in Iqaluit in the summer of 1999. Its mandate will be to provide "one window" access for Nunavut to that information and expertise in support of sustainable development, geoscience capacity building, education and training, and awareness and outreach. Integrating traditional knowledge with geoscience activities will be an ongoing activity.

MAKING THE RIGHT CONNECTIONS

Throughout the year, the GSC forged links with Nunavut agencies. GSC staff participated in the Nunavut Planning Commission's South Baffin Land-Use Planning Workshop in Iqaluit in October. This was the third in a series of meetings with community leaders, representatives of Inuit organizations, and government representatives. Information contributed by the GSC on the geology and mineral potential of Baffin Island will assist planning activities and subsequent environmental monitoring. Workshop participants commented on the positive economic impacts of GSC's recently released maps of the bedrock geology of the Iqaluit-Kimmirut area, inquired about the growing level of mineral exploration industry interest in the North Baffin region, and requested information on the potential of discovery of additional carving stone reserves.

DIGITAL DATA EXCHANGE

New connections between GSC and key Nunavut stakeholders have laid the groundwork for the exchange of digital geoscience information. An excellent program was forged with Nunavut Tunngavik Inc., which is developing a geographic information system and views geoscience knowledge provided by the GSC and its partners as an essential component of their project. Their interest in working with the GSC is an important step in building consensus towards the establishment of a Northern Geoscience Knowledge Network.

NEW GSC MAPS LEAD TO CARVING STONE DISCOVERIES

Carving stone and industrial rock sites were discovered in southern Baffin Island using new GSC maps. The discoveries stemmed from a joint initiative involving the Kimmirut town council and the Iqaluit-based Qikiqtaaluk Corporation. Of particular note was the discovery of an attractive marble. This is being assessed for jewellery and carving potential, and 40 tonnes of it have been shipped to New Brunswick for product testing and marketing. It is also being considered for use in the construction of the new Nunavut Legislative Building in Iqaluit. The accuracy and level of detail shown on the GSC maps is credited for the discoveries.

"MINERAL EXPLORATION AND DEVELOPMENT IS THE NUMBER ONE OPPORTUNITY FOR ECONOMIC DEVELOPMENT IN NUNAVUT."

Wayne Johnson, Nunavut Tunngavik Inc.

BAFFIN ISLAND PARTNERSHIPS DELIVER

Twelve months after the start-up of the North Baffin/Melville Peninsula Geoscience Knowledge Base compilation, final products were released. Partners included GSC, GNWT, Qikiqtaaluk Corp., and DIAND. Their objective was to pull together the geoscience base needed to help stimulate mineral exploration investment in Nunavut, while at the same time facilitating geoscience capacity building in northern communities. Products include maps of bedrock and surficial geology, geochemistry, mineral occurrences and metallogenic domains, a CD-ROM of the entire compilation, and a report.

Another joint multidisciplinary project, the Central Baffin Project, involving the same partners, was undertaken to provide geoscience information for resource assessment. Field work was conducted in the Longstaff Bluff area covering several research disciplines: geochemistry, remote sensing, Quaternary geology, metallogeny, and geochronology. Products and reports sparked much interest from mineral exploration companies.

NEW PRODUCTS

Northern Baffin Island and northern Melville Peninsula:

Bedrock geology compilation

By E.A. de Kemp and E.A. de Kemp
GSC Open File 3633. \$45
(\$58.50 outside Canada)

Geoscience compilation

By E.A. de Kemp and D.J. Scott
GSC Open File D3636. \$300
(\$390 outside Canada)

Surficial geology compilation

By L.A. Dredge, A.S. Dyke, D.A. Hodgson, M.J.G. Hooper and R.A. Klassen
GSC Open File 3634. \$30
(\$39 outside Canada)

Mineral deposits compilation and metallogenic domains

by D.F. Sangster
GSC Open File 3635. \$15
(\$19.50 outside Canada)

Geology of Carr-Kaminak-Quartzite lakes area, Kivalliq region

By D.A. Irwin, S. Hanmer, H.A. Sandeman, R.H. Rainbird, T.D. Peterson, C. Relf, J.J. Ryan, S.P. Goff, A. Mills and J.A. Kerswill
GSC Open File 3649. \$15
(\$19.50 outside Canada)

Kimberlitic indicator minerals in the GSC's archived till samples: Results of analysis of samples from the Baker Lake area and northern Baffin Island

by R.N.W. DiLabio and R.D. Knight
GSC Open File 3643. \$78.75 or \$45 for diskette
(\$102.40/\$58.50 outside Canada)

Reanalysis of 1775 lake sediments from regional surveys on Central Baffin Island

by P.W.D. Friske, S.J.A. Day, M.W. McCurdy and C.C. Durham
GSC Open File 3716. \$75
(\$97.50 outside Canada)

To order, see page 40



GEOSCIENCE SURVEYS

A COMPREHENSIVE NATIONAL GEOSCIENCE KNOWLEDGE FRAMEWORK FOR CANADA FORMS THE BASIS FOR SUSTAINABLE DEVELOPMENT OF CANADA'S MINERAL, ENERGY, WATER AND OTHER RESOURCES, LAND-USE DECISION MAKING, AND PUBLIC HEALTH AND SAFETY PLANNING LINKED TO NATURAL HAZARDS. GSC'S NATIONAL GEOSCIENCE MAPPING PROGRAM (NATMAP), A PARTNERSHIP WITH PROVINCIAL AND TERRITORIAL AGENCIES, IS ONE OF THE KEY MECHANISMS FOR DELIVERY OF THIS WORK.

Alberta Lithoprobe nears completion

The Alberta Basement Transect is well ahead of schedule for completion, with special issues of the *Bulletin of Canadian Petroleum Geology* and the *Canadian Journal of Earth Sciences* planned to present results. Regional-scale cross sections of the Alberta sedimentary basin will be released as GSC open files, representing the first such public domain data sets in western Canada. One focus has been an overview of crustal evolution in the Alberta Basin and the setting of the recent Alberta diamond plays. Publication of a paper in *Science* on the electrical structure of the mantle in Alberta, showed important differences between potentially diamondiferous mantle in northern Alberta and areas to the south. The project also addressed issues of continental evolution and the effects of basement structure on the evolution of a sedimentary basin. The reactivation of these old structures during younger sedimentation and petroleum migration, particularly in southwestern Alberta, is an area of controversy and ongoing research for the petroleum industry. ☒

Electromagnetic survey on ice road

The GSC, in partnership with Lithoprobe, conducted an innovative three-week electromagnetic survey in an old portion of the Precambrian Shield. The survey, along the 600 km ice road between Yellowknife and the Lupin Mine, used sensors lowered through the ice to the lake bottom to measure the electromagnetic field deep within the Precambrian crust of the Slave Geological Province. The measurements provided an image of the thickness of the cold, hard "lithosphere" above the warm, soft "asthenosphere" on which the upper part of the Slave Province floats, providing essential information for diamond exploration. This project was a pilot for a more extensive survey conducted in early 1999 and a key component of a major geoscience transect from Yellowknife to the Pacific Ocean. The critical extension of the experiment across the diamondiferous Slave Province was made possible through partnering with industry and DIAND. ☒

Western Superior Lithoprobe and NATMAP

This program integrates the NATMAP bedrock geoscience initiative in western Ontario-northeastern Manitoba with the Western Superior Lithoprobe transect and with ongoing work by the two provincial surveys, the GSC and the Canadian Mining Industry Research Organization (CAMIRO). Its goal is to provide a comprehensive framework for the exposed and subsurface geology, earth structure and mineral potential (base and precious metals, diamonds) across an under-explored part of the richly endowed Superior Geological Province. Through mapping, geochronology and geochemistry, integrated with seismic control on the third dimension, the project is developing new concepts to explain the formation of oceanic volcanic rocks (with high mineral potential) and older continental blocks. A major electromagnetic survey conducted by the GSC in collaboration with Lithoprobe, the universities of Manitoba and Toronto led to a better understanding of the subcrustal lithosphere in northwestern Ontario. ☒

GSC in northern Quebec

A diverse suite of geoscience survey work is carried out by the GSC in northern Quebec, in collaboration with Quebec's *Ministère des ressources naturelles* under their *Grand Nord* initiative. During the year, GSC was invited to take part in the Lake Peters mapping project, with scientists providing field mapping support and expertise in the petrogenesis of intrusive rocks. The GSC also contributed surficial geology expertise, conducting surveys of glacial flow indicators in several areas of northern Quebec. These have made it possible, for the first time, to distinguish flow patterns associated with the most recent glaciation from those related to previous glaciations. Results of these projects will have strong application to mineral exploration efforts in Quebec's north. ❖

Mapping northeastern Ellesmere Island

A mapping project, started this year, is the final leg in a long-term GSC program to complete mapping of the remote Parry Islands Fold Belt, which stretches from Prince Patrick Island in the western Arctic Islands to Ellesmere Island. It will comprise three years of reconnaissance scale mapping (1:250,000) in the rugged northeastern regions of Ellesmere Island. Excellent weather conditions and logistics support from the Polar Continental Shelf Project allowed for a productive 1998 field season that saw the completion of field mapping for more than 60% of the total project area. The project is a collaborative and jointly funded initiative of the GSC and the German geological survey (BGR). ❖

Lithoprobe: a model for geoscience research

THIS SUCCESSFUL PARTNERSHIP PROGRAM involving universities, the Natural Sciences and Engineering Research Council, GSC, and mineral and energy exploration industries provides a major opportunity for undertaking regional geophysical surveys to map the subsurface of the Canadian landmass, and to integrate results from these studies with those of geological and geochemical studies.

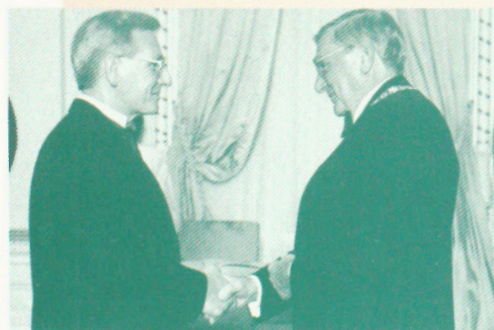
By the start of the new millennium, Lithoprobe will have mapped major segments across the Canadian landmass and offshore in three dimensions (surface, sub-surface) and through geological time, making fundamental breakthroughs in our understanding of how the continent was assembled over the past four billion years.

Lithoprobe's final phase, which started in 1998, is focused on study areas in the Northwest Territories, Yukon and northern British Columbia (SNORCLE Transect), in western Ontario (Western Superior Transect), and on a pan-Lithoprobe synthesis of the multidisciplinary results from all ten Lithoprobe study areas.

Collaboration with the mineral and energy exploration industries has resulted in significant technology transfer. For example, 3-D seismic survey techniques in crystalline rocks, developed by the GSC, have resulted in a tenfold increase in the effective depth of prospecting for minerals, reducing the need for many expensive test drillholes.

International reviews of Lithoprobe have been consistently outstanding. Scientists in Canada and abroad use Lithoprobe as a model of a

multidisciplinary geoscience program built on strong government-university collaboration and highly credible science.



Sgt. C. Coulombe, Rideau Hall

RON CLOWES, DIRECTOR OF LITHOPROBE AND A PROFESSOR AT THE UNIVERSITY OF BRITISH COLUMBIA, RECEIVED THE ORDER OF CANADA FROM GOVERNOR GENERAL, HIS EXCELLENCY ROMÉO LEBLANC, OCTOBER 22, 1998. THE AWARD UNDERSCORES THE HIGH ESTEEM IN WHICH BOTH DR. CLOWES' SCIENTIFIC LEADERSHIP AND THE LITHOPROBE PARTNERSHIP ARE HELD WITHIN CANADA.

Extension of the GSC-INRS agreement

ON NOVEMBER 12, 1998, THE AGREEMENT between the Institut national de la recherche scientifique (INRS) and the GSC establishing the Québec Geoscience Centre (QGC) was renewed for a five-year period. Aïcha Achab, QGC Director, Marc Denis Everell, Assistant Deputy Minister, Earth Sciences Sector, and Pierre Lapointe, INRS Director General signed the agreement.



Polar Margin Aeromagnetic Program

Canada (National Research Council, GSC, National Defence), Germany and Denmark continued acquisition and interpretation of aeromagnetic and gravity data in the Lincoln Sea in Canada's Arctic. The project is contributing to the understanding of the complex crustal structure and tectonic history between Greenland and Ellesmere Island. This fundamental characterization of the continental margin will be directly applicable to the assessment of sovereignty issues under the proposed United Nations' Convention on the Law of the Sea. The work also contributes to assessing the region's oil and gas potential, and, through linking ocean circulation models with paleocontinental reconstruction, is improving the understanding of the role of the Arctic region in climate change. ❖

EXTECH-II

SEEKING FUTURE OPPORTUNITIES
FOR CANADA'S MINING CAMPS

"IF THIS WAS A "REPORT CARD", THE PROGRAM RATES FROM AN A- TO A+ IN ALL AREAS, AND EXTECH-II IS A VERY EFFECTIVE PROGRAM. OF THE NINE SIMILAR OPINION SURVEYS THE AUTHOR HAS CONDUCTED DURING THE PAST SEVEN YEARS, THE EXTECH-II RATING IS THE HIGHEST HE HAS SEEN."

*D.M. Fraser Services Inc. and Three-D GeoConsultants Ltd.,
"An Impact Assessment of EXTECH-II, January, 1999*

The final year of field work on the joint GSC-New Brunswick Bathurst EXTECH-II project was completed. With the objective of generating new knowledge to address declining base metal reserves, the project has delivered new geophysical, geological and geochemical data for exploration in the Bathurst mining camp and similar geological environments elsewhere in Canada. An external evaluation of the impact and effectiveness of the project rated it very highly.

EXTECH-II resulted in an increase in exploration expenditures in the Bathurst area of \$2 – 3 million per year over the life of the project, and this level is expected to continue for the next decade. Thus, the combined expenditure of \$6.5 million by the

federal and provincial governments will stimulate incremental expenditures of \$24 – 45 million by industry.

Formal publication in the coming year of a compendium of scientific results, updated geological maps and a geophysical atlas, as well as an interactive web site and workshops, will further transfer the new information and technological advances.

At the end of the EXTECH-II project, the Bathurst mining camp will have the most comprehensive, publicly accessible geoscience database of any mining camp in the world. This knowledge infrastructure will support exploration for many years to come, and greatly increase the probability of discovery of new base metal reserves.

For more information, visit

[HTTP://EXTECH2.GSC.NRCAN.GC.CA/](http://EXTECH2.GSC.NRCAN.GC.CA/)

NEW PRODUCT

EXTECH-II GIS geoscience database, Bathurst Camp, New Brunswick

*By D.F. Wright, L.D. Kemp and W.D. Goodfellow
Open File D3693. \$50 (\$65 outside Canada)*

To order, see page 40

NATMAP

CANADA'S NATIONAL GEOSCIENCE MAPPING PROGRAM

NATMAP IS DESIGNED TO INCREASE THE LEVEL AND QUALITY OF GEOSCIENTIFIC MAPPING OF CANADA. NATMAP PROJECTS PULL TOGETHER TEAMS OF PROVINCIAL, TERRITORIAL, UNIVERSITY, INDUSTRY AND GSC RESEARCHERS. THEY HAVE BEEN AN OUTSTANDING SUCCESS IN TERMS OF SCIENTIFIC RESULTS, INNOVATION, IMPACT ON CANADIAN INDUSTRY, AND THE TRAINING AND DEVELOPMENT OF CANADIAN SCIENTISTS.

NATMAP MILESTONES FOR THE YEAR WERE:

NECHAKO WINDS UP

This project in the resource-rich, under-explored Nechako Plateau area of central British Columbia was completed on time, within budget and with significant new geoscience contributions. The team comprised over 50 scientists from the GSC, B.C. Geological Survey, B.C. Forest Service, universities, and mining and exploration companies. Results of bedrock and surficial mapping have been enhanced by integration with many site- and area-specific studies ranging from metallic and industrial mineral deposits to digital spatial modeling. In addition to maps and reports, all data will be available in computer-accessible, GIS-compatible format on CD-ROM disks and through the Internet www.ei.gov.bc.ca/~natmap/.

EASTERN CORDILLERA

Twelve new surficial geology maps of the Foothills between Calgary and the U.S. border were released, completing the surficial geology component of this project. The maps will aid regional planners in resolving issues arising from competing demands for oil and gas development, agricultural, forestry, and watershed land uses. They also define natural hazards to

be avoided in industrial, residential and recreational development. Cosmogenic dating (the use of cosmic ray exposure to date rocks and sediments) was used successfully in this project. This work laid to rest the hypothesis of an ice-free corridor along the eastern Alberta Foothills as a route south for the first peoples of North America during the climax of the last ice age.

WESTERN CHURCHILL

This partnership involving the GSC, GNWT and DIAND was initiated in 1997 to provide a comprehensive geoscience knowledge base for Nunavut's Kivalliq region, an area with gold, base-metal and carving-stone potential. Results to date have been impressive. New geochronological data has led to improved understanding of areas that are suitable targets for mineral exploration. New metallogenic studies suggest significant potential for discovery of porphyry deposits in the Kaminak and Woodburn greenstone belts. Regional ice-flow indicator mapping and detailed surficial geology studies in highly prospective areas have provided a geological framework for using surficial sediment as a prospecting tool. The project has attracted strong industry support, in particular through an innovative field workshop in isolated tundra conditions.

NATMAP

CENTRAL FORELAND

This project is mapping an economically important area in the foothills of northeastern British Columbia. During 1998, the first year of research involved a large contingent of up to 45 geologists from the GSC, industry, universities and the B.C. Geological Survey working from a field camp north of Fort St. John. By year-end, the project released five 1:50,000 scale geological maps.

WINNIPEG REGION

The GSC and Manitoba Geological Services Branch are cooperating to complete geological mapping of the Winnipeg region, extending work from the earlier Prairies NATMAP project to the north and west of the city. New surficial geology maps will clarify the glacial history of the area, define aggregate resources, better define the geological factors that influence shoreline erosion of Lake Winnipeg, and facilitate mineral exploration. Eight maps are in preparation, and work during the 1999 field season is coordinated with major GSC research programs on hydrogeology, Red River flooding and Lake Winnipeg shoreline erosion.

NEW PROJECTS

Ancient Pacific Margin Two years of planning and building partnerships went into developing this project. Its investigations along the western edge of Canada from Washington State to Alaska will focus on the ancient plate margin (more than 400 million years old) that provides a fertile setting for various types of mineral deposits, particularly Volcanogenic Massive Sulphide (VMS), sedimentary exhalative sulphide (SEDEX) and gold deposits. GSC's research partners are the B.C. Geological Survey and Yukon Geology Program.

Appalachian and Foreland Platform

Funding of this new five-year project puts in place the first building block for the collaborative, multidisciplinary, multi-agency endeavour "Geological Bridges of Eastern Canada". It will be led by the GSC and the geological surveys of New Brunswick and Newfoundland, with endorsement from the Quebec geological survey. The project will traverse segments of southern Quebec, northwestern New Brunswick and western Newfoundland, which represent core components of a jointly planned Geo-Atlas of the St. Lawrence.

NEW PRODUCTS

Geology, NATMAP Shield Margin Project area (Flin Flon Belt) Manitoba/Saskatchewan

By NATMAP Shield Margin Project Working Group
GSC Map 1968A. \$68.10
(\$88.51 outside Canada)

Geochronological compilation of the Superior Province, Manitoba, Ontario, Quebec

By T. Skulski and M. Villeneuve
GSC Open File D3715. \$15
(\$19.50 outside Canada)

Selected geoscience data from the Western Churchill NATMAP Project, Kivalliq Region, Nunavut: Volume 1

Compiled by L. Wilkinson and NATMAP
GSC Open File D3683. \$250
(\$325 outside Canada)

Magdalen Basin NATMAP - Onshore geological database

by G. Lynch, P.S. Giles, C. Deblonde, S.M. Bair, S.W.J. Piper, C. St. Peter, R.J. Héту, G. Pe-Piper, R. St. Jean, J.B. Murphy, F.W. Chandler and R.C. Boehner
GSC Open File D3564. \$75
(\$97.50 outside Canada)

Selected geoscience data from the Slave Province NATMAP project, District of Mackenzie, NWT - Volume II

Compiled by L. Wilkinson and the Slave NATMAP Geoscience Team
GSC Open File D3682. \$250
(\$325. outside Canada)

A wide range of surficial maps from NATMAP projects for the Foothills, Prairies, Oak Ridges Moraine, Shield Margin and Nechako regions are also available as GSC Open Files. Information is available from the GSC Bookstore.

To order, see page 40

WWW.NRCAN.GC.CA/GSC/NATMAP

NATMAP



MINERALS

GSC'S MINERALS RESEARCH PROVIDES GEOSCIENCE INNOVATION

AND INSIGHT THAT HELPS THE MINERAL EXPLORATION INDUSTRY DISCOVER THE RESERVES REQUIRED TO SUSTAIN CANADA'S POSITION AS ONE OF THE WORLD'S LEADING SUPPLIERS OF MINERALS AND METALS. IT ENSURES THAT THE CANADIAN GOVERNMENT HAS THE GEOSCIENCE INFORMATION NECESSARY TO FORMULATE MINERAL POLICIES IN AREAS OF FEDERAL JURISDICTION AND TO PROMOTE THE TECHNOLOGICAL CAPABILITY OF THE CANADIAN EXPLORATION SERVICES INDUSTRY.

NEW PRODUCTS

Lithological and alteration maps of the Hope Brook gold deposit, Newfoundland

By B. Dubé, K. Lauzière and E. Boisvert
GSC Open File 3606. \$30
(\$39 outside Canada)

GSC publishes a wealth of geoscience information in support of mineral exploration in Canada's glaciated landscape. Reports contain data on the abundance of gold, other trace elements, and kimberlite indicator minerals in glacial sediments and soils. They also describe tests of mineral exploration methods for gold and diamonds. These can have major impact by guiding the mineral exploration industry into new prospective areas and by defining the regional geochemical and mineralogical baseline for exploration at the property scale. Publications for 1998-99 documented results from areas in Ontario, Alberta, British Columbia and Nunavut. Contact the GSC Bookstore for more information: Open File reference numbers are 3601, 3643, 3654, 3675, 3687, 3707 and 3719.

To order, see page 40

\$1.4 million project looks at volcanogenic massive sulphides (VMS)

VMS deposits are an economic powerhouse, accounting for 20% of the total value of Canadian mineral production and 10% of Canadian gold output. This year, a GSC-led, industry-sponsored project to evaluate the size of the signature left behind by ancient seafloor hydrothermal systems during the generation of multi-deposit VMS camps was completed with significant results. The four-year project, which included researchers from the Manitoba Geological Services Branch and Carleton and Laurentian universities, studied the geological, mineralogical, geochemical and geophysical characteristics of three major sulphide camps in Manitoba, Ontario and Quebec, and Sweden's Skellefte mining district. The results have provided industry with key criteria for the recognition of potentially productive volcanic hydrothermal systems in ancient volcanic belts. Of note, this Canadian Mineral Industry Research Organization (CAMIRO) project was the first to institute annual workshops for report delivery, thereby more effectively transferring knowledge and techniques generated throughout the life of the project. ☒

Gold in Newfoundland

Industry interest remained strong in the Avalon Zone of Newfoundland during the second year of a gold metallogeny project carried out by the GSC in collaboration with the Newfoundland Geological Survey. Results confirmed the epithermal and porphyritic gold mineralization potential of this area. The *Voisey's Bay News Journal* reported that interest generated by this work has resulted in an increase in exploration activities in the area, translating into 1,200 exploration permits and the discovery of the Santana prospect. ☒

Seafloor minerals research discovers gold

A German-Canadian research team has discovered gold mineralization associated with a recently active submarine volcano. Mapping in largely uncharted waters in the vicinity of Lihir, Papua New Guinea, revealed six previously unknown volcanic cones with evidence of recent submarine volcanism and hydrothermal venting. Gold mineralization was found at the

Exploration methods for the Abitibi Greenstone Belt

GSC SCIENTISTS ARE WORKING WITH THE ONTARIO Geological Survey and the University of Waterloo to develop new geochemical exploration methods in the thickly drift-covered Abitibi Greenstone Belt, one of the most mineral-rich areas of Canada. Recent accomplishments include:

- *Detailed dispersal studies around gold deposits demonstrate the gold signature in glacial sediments and how till sampling can be used to explore for new gold deposits.*
- *New surficial geology maps in the Timmins, Ontario, area and a database of over 5,000 overburden drill-hole records from exploration companies provide key information on glacial transport directions, drift thickness, and bedrock topography.*
- *A regional geochemical survey of the Timmins area identified anomalous areas for new exploration. Kimberlites in the Kirkland Lake and New Liskeard areas are test sites for glacial dispersal studies as well as for developing new diamond exploration methods based on geophysics, biogeochemistry, and surficial geochemistry.*

GSC research in the Abitibi region is continuing, and future activities will attempt to define the geochemical signatures in surface soil over deeply buried ore deposits.

summit of one of the largest volcanoes. Epithermal gold associated with active submarine volcanism represents a new type of deposit that may become an important target for mineral exploration on land, in both nearby island chains and in ancient volcanic rocks such as those found on Canada's Precambrian Shield. ❖

Exploration technology

The Downhole Seismic Imaging (DSI) Consortium partnership with Falconbridge, Noranda, GSC, and the universities of Western Ontario, Alberta and Kiel (Germany) has developed novel instrumentation and successfully demonstrated its capability for mapping ore zones and structures at depth. During September 1998, Noranda Mining and Exploration Inc. conducted a 3-D surface seismic survey at the Bathurst mining camp in New Brunswick, applying technology developed by the GSC for mineral exploration. The Bathurst survey provided a good opportunity for the DSI Consortium to test the applicability of its new technology for deep mineral exploration by deploying a recently acquired multi-level probe in a borehole located at the centre of the seismic grid. Results are now being processed with the goal of producing images of a massive sulphide orebody. ❖

GSC technology transfer a success story

GSC TECHNOLOGY TRANSFERRED TO Chemex Laboratories of Vancouver has given this company a competitive edge and opened the doors to new revenues and jobs. The technology is a series of innovative state-of-the-art laboratory procedures for analysing chemical forms of elements in geological materials. The major application of this technology is in exploration for buried mineral deposits worldwide, but there is a growth area for it in environmental geochemistry (assessing toxicity, source and mobility of metals in the environment). This capability provides a technological edge to Canadian industry. In the first year alone, Chemex is enjoying additional revenues of about \$200,000 and has employed three new staff members.



GSC'S ANALYTICAL METHOD DEVELOPMENT LABORATORY IN APPLIED GEOCHEMISTRY RECEIVED A FEDERAL PARTNERS IN TECHNOLOGY TRANSFER AWARD IN RECOGNITION OF ITS COLLABORATION WITH CHEMEX LABORATORIES OF VANCOUVER. FROM LEFT, IRWIN ITZKOVITCH, NORANDA INC. (SPONSOR); GWENDY HALL, GSC; JACQUES LYRETTE, NATIONAL RESEARCH COUNCIL; AND ADRIANA ALEXANDRA (ACCEPTING ON BEHALF OF HENK BLOK AND BRENDA CAUGHLIN, CHEMEX).

Nickel exploration stimulated in Manitoba

Collaborative work by the GSC, Manitoba Energy and Mines, Falconbridge, INCO and the Carnegie Institute succeeded in correlating the Thompson Nickel Belt and the Fox River Sill, Manitoba. The project culminated with high precision dating by the GSC which showed that the two areas are part of a single magmatic event. Communication of the new model at several conferences triggered exploration permitting of the entire complex (greater than 50,000 hectares) and new geophysical surveys over the region. The mineral of interest is platinum, which occurs with sulphides in the gabbroic sill. The Thompson Nickel Belt has also been extended as an exploration target, as a direct result of industry follow up to an earlier release of new GSC aeromagnetic data that indicated the belt potentially extends 200 km north of Thompson, Manitoba.

The 1998 *Manitoba Mining and Exploration Review* attributes renewed industry interest in the Thompson Nickel Belt, one of the world's largest producing nickel regions, to the work of the GSC. It cites aeromagnetic data released by GSC in 1996, which indicated that the Belt "potentially extends 200 km northeast of Thompson", as the direct cause of this renewed exploration activity. ⊗



ENERGY

GEOSCIENTIFIC KNOWLEDGE ABOUT THE ENERGY RESOURCES CONTAINED IN CANADA'S SEDIMENTARY BASINS SUPPORTS THE ENVIRONMENTALLY RESPONSIBLE DEVELOPMENT OF THESE RESOURCES. GSC RESEARCH ON REGIONAL HYDROCARBON GEOSCIENCE IS CARRIED OUT WITH PROVINCIAL AND TERRITORIAL AGENCIES AND WITH INDUSTRY. INTEGRATED THEMATIC STUDIES FOCUS ON THE PROCESSES BY WHICH HYDROCARBON DEPOSITS ARE FORMED AND THE GEOLOGICAL CHARACTERISTICS OF KNOWN RESOURCES.

Atlas of Organic Petrography

A landmark scientific publication, the first petrographic atlas of its kind, was published in 1998. The *Petrographic Atlas of Canadian Coal Macerals and Dispersed Organic Matter* is illustrated with 450 captioned photomicrographs, most in full colour. The petrographic images extensively document the organic composition and distribution of Canadian coals and hydrocarbon source rocks from virtually every Canadian sedimentary basin. The atlas also contains updated maps of coal reserves and resources.

The atlas was a collaboration of the Canadian Society for Coal Science and Organic Petrology, the CANMET Energy Technology Centre and GSC, with contributions from provincial surveys, universities and industry. As an authoritative global reference, the volume is expected to have a long shelf life. It places Canadian organic petrology and petrologists in a globally acknowledged leadership position. The atlas may be ordered from the GSC Bookstore in Calgary (address on back cover). ☒

New oil assessment for Western Canada Sedimentary Basin

The GSC has revamped and revised the estimates of conventional oil resources in the Western Canada Sedimentary Basin, Canada's primary source of petroleum production. The new report, *Oil resources of Western Canada*, replaces estimates published in 1987, a GSC bestseller. The results of the new study are encouraging for Canada. It is expected that the undiscovered oil resource in the Western Canada Sedimentary Basin is $5,488 \times 10^6 \text{ m}^3$ in place. More than fifty years after the Leduc discoveries, these estimates favourably augment the initial in-place discovered reserve of $12,547 \times 10^6 \text{ m}^3$ (of which $881.2 \times 10^6 \text{ m}^3$ remained in 1996). The GSC calculations form the resource input to the National Energy Board's new study of Canadian petroleum supply, due for release in 1999. ☒

Oil resource potential of West Coast sparks debate

Another GSC resource assessment, *Petroleum resource potential of sedimentary basins on the Pacific Margin of Canada*, analyses the undiscovered petroleum potential on the Pacific Margin of Canada. The results of the study have been widely quoted in the media and have generated significant debate in British Columbia. Some provincial interest groups have proposed lifting the 13 year-old moratorium on offshore petroleum exploration as a method of augmenting and diversifying British Columbia's resource economy. Together with staff from NRCan's Frontier Lands Group and B.C. government departments, GSC experts have provided scientific information to the public and private sectors for an informed discussion of land use, resource development and environmental preservation. Portions of the B.C. offshore, particularly Hecate Strait and Queen Charlotte Sound, indicate potential for "Hibernia-like" accumulations of oil. ☒

GSC study leads to Chinese oil discovery

AS PART OF AN ONGOING PROGRAM of collaborative geoscience and technology transfer, the GSC carried out a study of oil types and sources in the Huiming Depression of the Bohai Basin in China. The resulting report contributed to locating and drilling two wells, both of which were commercial successes. These wells confirm a potential for several hundreds of millions of barrels of oil in the region. This has sparked strong interest on the part of subsidiaries of the China National Petroleum Corporation to strengthen collaborative studies and scientific exchanges with the GSC. The proposed studies will look at several Chinese petroleum basins. As part of the program, visiting Chinese scientists and engineers will become familiar with Canadian science and the technology used in the Canadian oil patch, to the mutual benefit of both nations.



GSC CALGARY DIRECTOR GRANT MOSSOP, EXCHANGES TOKENS OF FRIENDSHIP AND COLLABORATION WITH MR. WANG BINGHAI, LEADER OF THE CHINA NATIONAL PETROLEUM CORPORATION DELEGATION DURING THEIR CALGARY VISIT.

Hydrocarbon potential of the Laurentian Margin

The GSC has pursued collaborative activities with oil companies interested in the sedimentary basins of the Laurentian Margin in eastern Canada. Work was done with Shell Canada and Encal Energy to identify the reservoir rock potential of Anticosti Island. Studies of sedimentology and diagenesis, combined with geochronological analyses, are making it possible to specify the exact age of hydrocarbon migration and identify exploration target areas. Work was also carried out with PanCanadian Petroleum in the Humber Zone of the Quebec Appalachians with a view to clarifying the stratigraphic and structural context and identifying the hydrocarbon potential. ⊗

New insights into basin evolution

Mountain building results in a depression of the crust immediately adjacent to the rising mountains and a welt or crustal uplift beyond that, because of the rigid character of crustal rocks. A GSC study of fossil pollen from flowering plants (angiosperms) in Late Cretaceous and Tertiary rocks of the Western Canada Sedimentary Basin has resulted in the development of a new model for this phenomenon. This new interpretation has dramatic implications for correlations of strata across the basin and brings a new perspective to petroleum exploration. The study was conducted in collaboration with scientists from universities (Rhodes, Alberta, and Toronto), and the Royal Tyrrell Museum of Paleontology. ⊗

Williston Basin study

The GSC completed an integrated geophysical-geological transect study of the sedimentary strata of southeastern Saskatchewan and southwestern Manitoba. The region encompasses zones of significant petroleum exploration activity and interest, particularly so in light of recent discoveries in hitherto unproductive Ordovician rocks, and the fact that the Government of Saskatchewan has embarked on a program of "deep rights reversion". The Saskatchewan government program makes it attractive for oil and gas companies to either explore for petroleum on their leasehold lands or relinquish them to the Crown. The principal finding of the GSC study is that the lower Paleozoic stratigraphy and structure are controlled in significant measure by the structure and disposition of the underlying Precambrian basement. As a result of the study, known oil plays are better understood and possible new oil plays are brought to light. ☒

GSC helps in Sable Island pipeline design

GSC's geomagnetism experts helped improve the design of the new Maritimes and Northeast Pipeline being built through Nova Scotia and New Brunswick to carry natural gas from the Sable Island gas field to U.S. markets. All pipelines are fitted with protection systems that regulate the electrical potential between the pipe and the soil to prevent corrosion of the pipeline. The new pipeline passes through a region where natural electric currents, generated by geomagnetic storms and the tidal movement of seawater through the earth's magnetic field, affect the electrical potential of the pipeline. GSC computer models were used to predict the effect of these currents, and this information enabled the pipeline company to design a system that minimizes the effect of the currents on the pipeline. ☒

NEW PRODUCTS

Oil resources of Western Canada

By P.J. Lee
GSC Open File 3674. \$3,500
(\$4,550 outside Canada)

Petroleum resource potential of sedimentary basins on the Pacific Margin of Canada

By P.K. Hannigan, J.R. Dietrich, P.J. Lee and K.G. Osadetz.
GSC Open File 3629. \$40
(\$52 outside Canada)

A petrographic atlas of Canadian coal macerals and dispersed organic matter

Edited by J. Potter, L.D. Stasiuk, and A.R. Cameron
CSCOP, GSC and CANMET joint publication.
\$124.77 (\$138.50 outside Canada)

Petrographic, physico-chemical, and coal facies studies of ten major seams of the Sydney Coalfield of Nova Scotia

By P.A. Hacquebard
GSC Bulletin 520. \$11.30
(\$14.70 outside Canada)

Biochronology and paleontology of Lower Jurassic (Hettangian and Sinemurian) radiolarians, Queen Charlotte Islands, B.C.

By E.S. Carter, P.A. Whalen, and J. Guex
GSC Bulletin 496. \$44
(\$57.20 outside Canada)

Atlas of common benthic foraminiferal species for Quaternary shelf environments of Western Canada

By R.T. Patterson, S.M. Burbidge, and J.L. Luternauer
GSC Bulletin 503. \$17.45
(\$22.70 outside Canada)

DINOFLAJ

by R.A. Fensome, A. MacRae and G.L. Williams
GSC Open File 3653. Various packages and prices.

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STEP: SCIENCE AND TECHNOLOGY EXCHANGE PROGRAM

STEP is a new program designed to provide opportunities for external partners to exchange expertise and share operating costs for mutually beneficial projects with the Geological Survey of Canada.

STEP's main objective is to foster partnerships that will help meet strategic research goals of both sides. The foundation of the program is work exchanges and research partnerships that will broaden the skill sets and experience of participating staff and organizations. The exchange of expertise is intended to generate new synergies and dynamics to enhance the project.

Research partnerships will capitalize on existing capacity in academia, government, industry and other institutions to generate new knowledge and research in areas of interest for the Canadian earth science community.

Participation is open to any company, professional association, university, centre of excellence, or government agency.

For more information, visit: http://www.nrcan.gc.ca/ess/chiefgeo/enhance_e.html

Mackenzie Valley aeromagnetic survey

The GSC, with funding from Canada's exploration community, acquires high-resolution regional aeromagnetic data over many regions in Canada in support of GSC programs and provincial/territorial needs. Participants benefit from cost-shared, high-quality data acquisition and from the expertise of the GSC's aeromagnetic group, which has helped establish industry standards for the acquisition of aeromagnetic data.

A multi-year aeromagnetic survey was initiated this year over the Mackenzie Valley, NWT, the site of one of the greatest hydrocarbon reservoirs in

western Canada. Aeromagnetism is a fundamental geoscience tool for such remote, difficult-to-map regions and, for this area, where there are significant gaps in coverage in the National Aeromagnetic Data Base. Similar GSC surveys over southern Alberta and Saskatchewan have also fostered a demand by the petroleum industry for high resolution aeromagnetic data.

For information, contact:
Regional Geophysics
Telephone: (613) 996-9624
Fax: (613) 952-8987
Website:
<http://gdinfo.agg.nrcan.gc.ca/> ✕



NRCan

GAS HYDRATES

PIONEERING RESEARCH IN THE ARCTIC

GAS HYDRATES ARE COMPOSED OF ICE AND FROZEN GASES SUCH AS METHANE. FIRST DISCOVERED IN NATURE ONLY 30 YEARS AGO, THEY ARE FOUND AT OR NEAR THE SURFACE IN NORTHERN ENVIRONMENTS OR BENEATH CONTINENTAL SHELVES. HYDRATES ARE THE SECOND-LARGEST CARBON TRAP (AFTER CARBONATE ROCKS) AND ARE VERY SENSITIVE TO TEMPERATURE. HOW CLIMATE WARMING WILL AFFECT METHANE RELEASE FROM HYDRATES IS UNKNOWN. METHANE IS A VERY EFFICIENT GREENHOUSE GAS, AND CHANGES IN THE AMOUNT OF IT IN THE ATMOSPHERE COULD HAVE A MAJOR IMPACT ON CLIMATE.

In February 1998, an international science team, led by the GSC, carried out a month-long study north of Inuvik in the Mackenzie River Delta, NWT, that will increase our understanding of natural gas hydrates. A 1,140 metre-deep research well was the focus of this cooperative research program between the Japan National Oil Corporation and the GSC. Other participants included the Japan Petroleum Exploration Company and the U.S. Geological Survey.

Much of the world's gas hydrates occur in polar regions and areas with permafrost. These are regions where current predictions say future warming caused by carbon dioxide build-up will be the greatest. With permafrost underlying about 50% of our landmass, the current effort in Canada is to determine where hydrates exist, how they got there, how much there is, how the gas is released from the solid material, how vulnerable they are to global warming, and, in arctic coastline areas, to a rise in sea level. Fundamental laboratory work is also

underway to understand the physical properties and kinetics of hydrates in natural soil materials. Plans are in place to participate in a major scientific drilling investigation in Alaska to sample and test gas hydrates.

Estimates of hydrate volumes in Canada and world-wide have been imprecise. Now, because of the high-quality data from exploration wells in northern Canada, the GSC is in a good position to provide better estimates. The Mackenzie Delta has been used as a test site in method development. Results have been published both as papers and maps, and similar data are being assembled for the rest of northern Canada. GSC staff are working with colleagues in the United States and Russia to complete circumpolar maps and make firmer projections of climate impact. Advances have also been made in laboratory testing of natural gas hydrates in sediments, allowing quantification of hydrate behaviour during warming.

For more information, visit

[HTTP://STS.GSC.NRCAN.GC.CA/PAGE1/HYDRAT/HYDRATES.HTML](http://sts.gsc.nrcan.gc.ca/page1/hydrat/hydrates.html)



HYDROGEOLOGY

GEOSCIENCE SUPPORTING GROUNDWATER MANAGEMENT

GROUNDWATER IS A STRATEGIC NATURAL RESOURCE THAT IS VITAL FOR SUSTAINING CANADIAN ECOSYSTEMS. IT IS ESSENTIAL TO THE WELL-BEING AND HEALTH OF CANADIANS AND TO THE VIABILITY AND GROWTH OF THE CANADIAN ECONOMY. AN INVENTORY OF GROUNDWATER RESOURCES AND A CLEAR UNDERSTANDING OF THE GEOLOGY THAT CONTAINS THEM ARE FUNDAMENTAL FIRST STEPS TOWARDS THE RESPONSIBLE AND EFFECTIVE MANAGEMENT OF THIS CRUCIAL FRESHWATER RESOURCE.

The GSC is well positioned to provide expertise for groundwater-related geological studies, and it has been steadily strengthening its hydrogeology program over the last few years. As a national organization, GSC's efforts are focused on facilitating, with a variety of partners, methodology development for acquiring and synthesizing information required for regional, cross-boundary and long-term issues relating to groundwater. In 1998, the GSC strengthened its hydrogeology program by staffing a Chief Hydrogeologist position at its Quebec office.

GSC's current hydrogeology projects span the country, both in densely populated urban areas and in important agricultural regions. All are built on a foundation of innovative field and digital mapping techniques, broad partnerships, and the timely communication of results to stakeholders.

LAURENTIAN PIEDMONT, QUEBEC

The Laurentian Piedmont, which extends from the Ottawa Valley to Charlevoix, is a major hydrogeological feature of southern Quebec. The GSC is mapping its aquifers to gain a better understanding of the dynamics of groundwater flow in unconfined aquifers located in former Champlain Sea marine deltas, and to evaluate their potential. The project aims to develop a methodology for mapping granular aquifers and for integrating diverse geoscience data in a hydrogeological database that can be used for groundwater management and protection.

OAK RIDGES MORAINÉ, ONTARIO

The Oak Ridges Moraine hosts a major groundwater resource for the Greater Toronto Area, and the GSC is nearing completion of a highly successful project in this area. In addition to shedding new light on the hydrogeology of the moraine, the project has established new methods for evaluating groundwater resources, applicable to other areas. The GSC will continue to provide unbiased scientific advice about this strategic watershed. The project has opened doors to new partnerships and new initiatives, including a possible role in International Joint Commission deliberations on Great Lakes water issues.

WINNIPEG REGION, MANITOBA

The City of Winnipeg's municipal water is drawn from Shoal Lake, but much of its industrial supply, and virtually all water in rural regions, is obtained from groundwater from thousands of wells that utilize two aquifers formed in sedimentary rocks. The sustainable capacity of the system is an increasingly important topic, so greater knowledge regarding replenishment is needed. Groundwater use in the region is constrained by an unstable interface with saline waters to the west. To facilitate sustainable groundwater-reliant economic development in the region, to protect existing utilization, and to coordinate management across the International Boundary, enhanced knowledge of the dynamics of this groundwater system is being obtained by GSC in cooperation with provincial agencies and universities.

NEW PARTNERSHIPS

Prairies: GSC and the Prairie Farm Rehabilitation Administration signed an agreement in 1998 for collaborative groundwater research and mapping studies on shallow aquifers in the Prairies. This partnership grew from the need to address issues of the sustainability of soil and water resources in the agricultural lands of the Prairies. The first project deals with issues and constraints linked to managing hog manure, and the need to provide guidance on best practices in preventing harm from it to soils and underlying groundwater resources. Building on expertise and technology originally developed for coal studies, GSC mapped the shallow sediments and modeled groundwaters at three test sites — one each in Manitoba, Saskatchewan and Alberta — drawing together the data and GIS standards and approaches necessary to generalize the findings to other sites.

Montréal area: In December, the GSC signed the first of several agreements with the Association of Professionals in Economic Development of the Laurentians for a three-year hydrogeological research and development partnership involving four municipalities: Argenteuil, Deux-Montagnes, Mirabel and Sainte-Thérèse-de-Blainville. A range of other federal, provincial agencies and Quebec universities will also take part. The research team will study the fractured aquifers of the region, with the goal of providing the municipalities with knowledge and tools to better understand and manage their water resources.

NEW PRODUCTS

Digital elevation model, Greater Toronto Area, southern Ontario, and Lake Ontario bathymetry

By F.M. Kenny, J. Paquette, H.A.J. Russell, A. Moore and M.J. Hinton
GSC Open File D3678. \$289.65
(\$376.55 outside Canada)

Sediment thickness of the Greater Toronto and Oak Ridges Moraine areas, southern Ontario

By H.A.J. Russell, A. Moore, C. Logan, F. Kenny, T.A. Brennand, D.R. Sharpe and P.J. Barnett
GSC Open File 2892. \$15
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Cartographie hydrogéologique régionale du piémont laurentien dans la MRC de Portneuf:

Géologie et stratigraphie des formations superficielles

by M. Parent, Y. Michaud, É. Boisvert, A.M. Bolduc, N. Fagnan, R. Fortier, M. Cloutier and A. Doiron

Hydrostratigraphie et piézométrie des aquifères granulaires de surface

by N. Fagnan, Y. Michaud, R. Lefebvre, É. Boisvert, M. Parent, R. Martel, D. Paradis and D. Larose-Charette

Hydrogéochimie des eaux souterraines

by É. Bourque, Y. Michaud, R. Lefebvre and É. Boisvert

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Water quality of the carbonate rock aquifer, southern Manitoba

By S.E. Grasby, R.N. Betcher and W.J. McDougall
GSC Open File 3725. \$56.50
(\$73.50 outside Canada)

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HAZARDS AND ENVIRONMENT

KNOWLEDGE PROVIDED BY THE GSC ABOUT CANADA'S GEOLOGICAL HAZARDS (EARTHQUAKES, VOLCANOES, MAGNETIC STORMS, LANDSLIDES), POTENTIALLY HAZARDOUS GEOLOGICAL CONDITIONS (PERMAFROST, NATURALLY OCCURRING METAL COMPOUNDS) AND ENVIRONMENTAL ISSUES (CLIMATE CHANGE, POLLUTION) PROVIDES THE BASIS FOR SOUND PLANNING THAT TOUCHES DIRECTLY ON THE SAFETY AND HEALTH OF CANADIANS.

GSC part of \$100 million Red River Flood Protection Program

On January 27, Minister Lloyd Axworthy announced federal funding (\$50 million over four years, to be matched by the Province of Manitoba) to upgrade flood protection measures in the Red River Valley for farms, businesses and homes, community diking and a range of other activities. The funding includes \$1 million for GSC over the next four years to continue developing a comprehensive geoscience knowledge base that will enhance understanding of the flooding hazards of the region. This will include investigations of the long-term flood history of the Red River and the geological controls relevant to flooding. GSC's research will provide a basis for assessing risks and will support decision-making on appropriate long-term remediation measures and land use. ☒

Landslides in the Saguenay area

The GSC continued to study landslide dynamics in the Saguenay as part of the federal action plan put in place following the devastating flooding of 1996. Landslide hazard areas in the municipality of Hébertville were the focus of detailed surveys that will enable the Quebec Department of Transport to determine the precise boundaries of unstable sectors. As part of an historic review of mudflows in the La Baie area, a preliminary analysis of dates obtained on buried organic material revealed that the earthquake of 1663 (estimated Magnitude 7) had a significant impact on all clay slopes in the region. The potential ability of earthquakes to trigger major landslides is an important aspect of the study of slope stability, and these results emphasize the importance of a paleoenvironmental approach to determining the boundaries of hazard areas and, thus, to establishing safe land management practices. ☒

Tracking emissions from coal-fired power stations

In collaboration with most of Canada's major coal-fired utility companies and government environment departments, the GSC continued its research into the elemental characteristics of milled coals, power plant ashes, stack gases and emitted particulates. Three studies were completed in 1998: at the Wabamun and Keephills plants in Alberta and the Lignan plant in Cape Breton. Special moss traps are deployed to sample emitted materials downwind from the stations. New analytical and petrographical methods are then applied to differentiate natural deposition and human deposition of air pollutants, metals, polycyclic aromatic hydrocarbons (PAHs) and radionuclides. In most cases, emissions fall well within environmental guidelines. There are ongoing studies in Saskatchewan power plants and at other Alberta and Nova Scotia utilities. ☒

Urban earthquake hazard in Pacific Northwest

GSC researchers took part in a marine seismic survey of Puget Sound, Strait of Georgia and Strait of Juan de Fuca with experts from the U.S. Geological Survey and six Canadian and U.S. universities. Their objective was to image the geological structure deep beneath the region, information that will allow researchers to understand the structural response to the active tectonics occurring in this area and to identify potential geological hazards. Seismic velocities were also measured, and these will be used to identify areas where earthquake shaking is predicted to be most intense. The use of a large sound source in the seismic experiment caused considerable concern to local environmental groups, and much effort went into public outreach to explain the scientific objectives and technology used. Biologists collected information on the effects of sonic bursts on marine mammals; this will be used to design future seismic surveys. ☒

Metals in the environment (MITE)

GSC'S FIVE-YEAR MITE INITIATIVE completed its second year with significant milestones in developing strong research partnerships. With other government departments, the GSC helped establish the MITE Research Network, with funding from the Mining Association of Canada and the Ontario Power Generation Corporation. The Research Network is the focus of university, government and industry collaborative research. It received funding from NSERC to support a program of university-led research. NRCan also signed an agreement with the Mining Association, Environment Canada, and Fisheries and Oceans, for a collaborative program on metals in the environment research supported by industry funding.

The GSC completed the first phase of a major multidisciplinary study, under its MITE initiative, on the effects of metals from point sources in the region around the Horne smelter at Rouyn-Noranda, Quebec. Work has focused on snow, lake, soil, peat and tree geochemistry. Isotopic and metal dendrochemical results obtained from locations about 7 km from the smelter show an abrupt change after 1928, the year the smelter commenced operation, and are in sharp contrast with data obtained from a control site established in the Grande rivière de la Baleine area. Similarly, peat core chemistry reflects the onset of smelter operations, suggesting that these sampling procedures help establish natural metal backgrounds, and can provide a historical record of smelter emissions. The spatial patterns of surface metal enrichment in snow, soils, peat and lake sediments are all similar, with recognizable enhancements of metal levels above background levels extending 40 to 50 km from the smelter. These findings are similar to previous results for soils around the Flin Flon smelter in Manitoba.

“THE AVAILABILITY OF THE GSC DATA HAS PERMITTED THE REASSESSMENT OF POTENTIAL PROPERTY LOSSES DUE TO EARTHQUAKES, BY A CALIFORNIA CONSULTING FIRM USING THEIR PROPRIETARY SOFTWARE. THE REDUCTION IN POTENTIAL INSURANCE PAY-OUTS WAS ESTIMATED TO BE 30 TO 50% . ONE LOCAL INSURANCE COMPANY ESTIMATED ITS ANNUAL REDUCTION IN POTENTIAL PAY-OUTS AT \$500 – 700 MILLION. THIS REVISED LOSS ESTIMATE HAS REDUCED THE PRESSURE FOR THE INSURANCE COMPANIES TO INCREASE PREMIUMS OR INCREASE DEDUCTIBLES...”

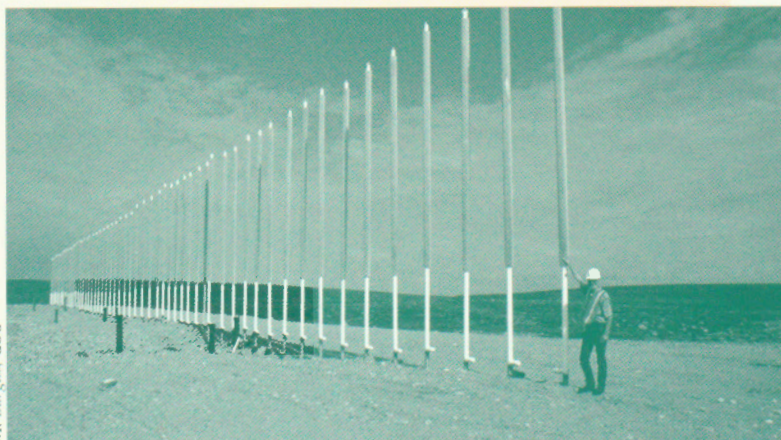
Michael Watson
“An Evaluation of Two GSC Geological Hazards and
Environmental Geoscience Program Projects”

Environmental assessments

GSC SCIENTISTS PLAY A MAJOR ROLE in NRCAN's participation in the environmental assessment of major industrial and development projects subject to the Canadian Environmental Assessment Act (CEA). Geoscience expertise is necessary to ensure that the proponents of any development have adequate knowledge and understanding of the physical environment, have made an adequate assessment of the effects of the project on the environment, and have identified appropriate design or mitigative measures to minimize adverse environmental impacts.

GSC expertise is required at many stages in the assessment review process: project screening, development of assessment guidelines, technical review of submissions, participation in technical working groups and public sessions, and appearance as expert witnesses at CEA Panel hearings.

During 1998-1999, GSC scientists contributed to the environmental assessment reviews of 18 projects, including highways, mines, harbours, and tourist resort and hydroelectric development. Major projects included the Voisey's Bay Mine and Mill Project and the Diavik Diamonds Project.



M. Burgess, GSC

Thermosyphon tubes used to maintain a frozen core impermeable dam at the BHP Ekati Diamond Mine, NWT, which opened in 1998. GSC scientists provided expertise on permafrost and related geotechnical issues as part of NRCAN's environmental assessment of the project.

Seismic risk in southern Ontario

Ontario Hydro is providing funds to the GSC for the reinterpretation of seismic reflection data in the Grenville Province-Great Lakes area. New high-resolution aeromagnetic data have been acquired in the International Boundary area, extending from Toronto to Buffalo, to fully exploit the potential benefits of integration with the extensive seismic database. The new results provide clear structural constraints on the Clarendon-Linden structural zone, providing important information for seismic hazard assessment in southern Ontario. ☒

Measuring Canada's volcano and earthquake hazard

GSC's acquisition of new data on recent volcanics in the Whitehorse, Yukon, area has provided a more precise picture of the episodic nature of recent volcanism. This provides a basis for developing models of eruptive cycles of the dormant and active volcanoes of western Canada. New research strategies focus on establishing improved documentation and episodicity of Cordilleran volcanism, which will allow for better volcanic and earthquake hazard risk assessments. ☒

Landslide inventory completed

A major inventory of landslides has been compiled for 80% of the Yukon (mostly south of 66°N and the Beaufort Sea coast). Because regions where a significant number of landslides have occurred are also the most susceptible to future landsliding, this compilation will help identify hazardous areas. It will be of benefit in the planning of transportation and pipeline routes and coastal facilities, and in the assessment of environmental risk. ☒

New national glaciology program

A new national program resulted from an agreement between NRCan and Environment Canada (EC) that amalgamated EC's Cordilleran glacier program with GSC's Arctic Islands glacier and ice cap program. The GSC is now responsible for developing and delivering the Canadian glacier research program which detects, monitors and assesses climate change and pollution as recorded by glaciers. The amalgamation ensures that a critical mass of core competencies will remain within the federal government, allowing Canada to maintain its research capacity in glaciology and fulfil commitments to international global change organizations. ☒

Team approach to predicting space weather

Researchers from the GSC, Canadian universities and the Canadian Space Agency are mapping out a ten-year national plan for space weather research in Canada. Space weather is caused by eruptions (solar flares) on the Sun, and can lead to magnetic storms and other disturbances in Earth's space environment. Better understanding of space weather will improve our ability to predict disturbances that can damage power grids, pipelines and satellites. GSC's strong links with industry, through its geomagnetism forecasting service and joint research projects, provide the space weather team with a view of the pragmatic, real-world needs of these clients. The goal of the initiative is to generate collaborative programs on space weather, with government, universities and industry working together. ☒

NEW PRODUCTS

Geomorphic effects and impacts of severe flooding: photographic examples from the Saguenay Area, Quebec

By G.R. Brooks and D.E. Lawrence
GSC Miscellaneous Report 62. \$8.75
(\$11.40 outside Canada);
colour slide set \$20 (\$26 outside Canada)

Inventaire des cicatrices de glissements au Saguenay In: Géologie des formations superficielles, Saint-Fulgence et La Baie, Québec

By S.J. Paradis, M. Parent, D. Perret and C. Bégin
GSC Open File 3710. \$30
(\$39 outside Canada)

Quantitative prediction models for landslide hazard assessment

By C.F. Chung and J.M. Shaw
GSC Open File 3692. \$15
(\$19.50 outside Canada)

Geology and natural hazards of the Fraser River Delta, B.C.

By J.J. Clague, J.L. Luternauer, and D.C. Mosher
GSC Bulletin 525. \$48
(\$62.40 outside Canada)

To order, see page 40



C. Hopkinson, Wilfrid Laurier Univ.

PEYTO GLACIER, SITUATED IN THE EASTERN SLOPES OF THE CANADIAN ROCKY MOUNTAINS, IS ONE OF THE PRINCIPAL RESEARCH SITES OF THE GSC'S NATIONAL GLACIOLOGY PROGRAM. GLACIER MASS BALANCE, CLIMATE CHANGE, REMOTE SENSING AND WATER RESOURCE STUDIES ARE CONDUCTED IN PARTNERSHIP WITH ENVIRONMENT CANADA'S NATIONAL WATER RESEARCH INSTITUTE, ALBERTA ENVIRONMENTAL PROTECTION, WILFRID LAURIER UNIVERSITY AND THE UNIVERSITY OF TORONTO.

CLIMATE CHANGE

FACING THE CHALLENGE

THE EARTH'S CLIMATE IS CHANGING, AS IT ALWAYS HAS. IT IS NOW CLEAR, THOUGH, THAT HUMANS ARE INFLUENCING GLOBAL WARMING — PARTICULARLY THROUGH ACTIVITIES THAT RELEASE GREENHOUSE GASES INTO THE ENVIRONMENT.

Global efforts are underway to reduce these emissions, but it will take a rapid 50% reduction in CO₂ emissions today to stabilize at concentrations that will be higher than those the world has seen over the past 200,000 years and more. That given, it is highly probable that some level of global warming will continue.

Canada is enhancing its predictive capability on several fronts to deal with this issue. Current efforts support three priority areas: **mitigation** (the reduction of emissions), **climate system science**, and **impacts and adaptation**. The GSC contributes to the latter two.

CLIMATE SYSTEM HISTORY AND DYNAMICS

The GSC has long researched past environments and climates. Today, its work is sharply focused on paleoenvironmental reconstructions of past periods of the Earth's history. This builds a better understanding of climate system dynamics, including the parameters that control climate. It also provides targets against which atmospheric modellers can test their models. If models are capable of reproducing known past climatic conditions, they can be used with greater confidence for forecasting future change. The GSC's research, which is carried out in collaboration with universities, includes:

Glaciology Ice cores from various sites in the circumpolar region are being studied as part of a GSC-led international project. Researchers are evaluating the scale of climate change on a circumpolar basis and determining what the pollutants are, where they come, how climate and the levels of pollution in the entire region have changed in the past, and whether they are changing now. The ice-core records put modern climate changes into perspective, and may allow natural changes to be separated from those induced by human activity. GSC's glaciology group has been monitoring the High Arctic ice caps for more than 30 years, producing the world's longest polar glacier records.

Ice core and snow-pollution studies now extend to the high alpine regions of the Cordillera (for example, Mount Logan, Yukon) to provide a high resolution paleoclimate/pollution record for the North Pacific region. Several other sites in the Rocky Mountains are under study to produce climate and pollution perspectives dating back to the beginning of the Industrial Revolution.

Dendrochronology GSC's studies have helped document climate changes in eastern Canada. Dendrogeochemical series (stable isotopes, metals and nutrients in tree rings) have been developed for

boreal and subarctic regions, and these will be used to reconstruct moisture regime and temperature variations during past centuries and to evaluate the ecosystem's response to natural disturbances such as forest fires. The GSC has also contributed to the monitoring of present climate conditions in subarctic regions by participating to the maintenance of the meteorological stations network in northern Quebec.

Carbon sources and sinks The climate system is dynamic, and the carbon cycle is part of it. Carbon is either bound or released on a continual basis depending on local conditions. Peatlands cover 14% of Canada and are one of the largest potential natural sources of greenhouse gases, including carbon. Among the four different peatland classes, there are more than 300-fold differences in the volume of greenhouse gas emissions possible, and each class has diverse morphologic and permafrost characteristics. GSC's new *Peatlands of Canada* map will be the first comprehensive national map to show the distribution of these four classes. Research by the GSC, in cooperation with Agriculture and Agri-foods Canada, will lead to the development of a model for estimating the amount of carbon stored in Canadian peatlands that is expected to be affected by climate warming. The GSC also predicts potential peatland sensitivity to the effects of climate warming.

IMPACTS AND ADAPTATION

Adaptation involves making socio-economic adjustments to deal with impacts of current climatic variability and with those expected as a result of future climate change. To be effective, adaptation strategies must be based on accurate assessments of the sensitivity and vulnerability of Canada's various regions and its economic sectors to climate-induced impacts. Changing climate conditions must be considered when planning infrastructure and long-term natural resource use. Adaptation to climate change is a relatively new concept, and it will require substantial cooperation from all stakeholders and levels of government.

Part of the federal government's Climate Change Action Fund is allocated to research on climate change impacts and adaptation. In 1998, the GSC established the Adaptation Liaison Office to coordinate implementation of this program. The goal is to develop an appropriate knowledge base that can support the decision-making needed for Canada's efforts to adapt to climate impacts. These efforts are fundamental to Canada's national strategy to deal with climate change. More information, is available at the website:

<http://sts.gsc.nrcan.gc.ca/adaptation>

Examples of GSC research in support of adaptation include:

Slope stability Geomorphic processes, including slope processes, are climate dependant. Indeed, some forms of slope movement, ranging from soil creep to slope failure, are climate driven. Effective adaptation strategies to avoid potential climate change impacts linked to slope stability must be based on an understanding of the spatial variability, dynamics and relation to climate. High hazard areas must be delineated so that they can be avoided or that structures (e.g. pipelines, railways) can be designed to address the hazard.

The GSC is investigating Alpine slope movements in the Cordillera, particularly in sensitive east-west transportation corridors such as the Fraser Canyon, and in the oil- and gas-rich Fort St. John area of British Columbia. In the Arctic, permanently frozen ground is now creeping just like ice in glaciers. The GSC is documenting a number of sites and has collected detailed measurements for more than 12 years. Movement is being related to climate.

In eastern Canada, the GSC is studying the stability of clay slopes in Ontario and southern Quebec, and documenting the relationship between precipitation, runoff along slopes and landslides. In southern Quebec, several time scales were considered in order to place historic and current observations in an Holocene context. The response of the "slope system" to various meteorological events was approached from a multidisciplinary perspective, integrating geomorphology, paleogeography, mechanics and hydrogeology.

Storms, sea-level rise and coastal erosion The GSC is studying rapidly changing coastal systems in Atlantic Canada, where rising sea levels contribute to widespread shoreline erosion and landward coastal retreat. Seabed mapping has revealed former lakes and rivers in Northumberland Strait, drowned shorelines off Newfoundland, and submerged estuaries off Nova Scotia. Recent studies provide clear evidence of episodic sea-level rise and coastal change. Severe storm impacts documented along the Nova Scotia coast are contributing to improved hazard assessment and mapping. A study of coastal sand budgets and shore dynamics on Prince Edward Island's north shore is helping to improve prediction of climate change impacts and coastal erosion, as well as providing realistic solutions for beach and dune conservation, estuarine management, and navigation safety in inlets to small-craft harbours.

NEW PRODUCTS

Sensitivity of the coasts of Canada to sea level rise

by J. Shaw, R. B. Taylor, D. L. Forbes, M.-H. Ruz and S. Solomon
GSC Bulletin 505. \$21.30
(\$27.70 outside Canada)

Geomorphological processes in the alpine areas of Canada: the effects of climate change and their impacts on human activities

by J.M. Ryder. GSC Bulletin 524. \$24.60
(\$32 outside Canada)

Geomorphic systems of the Palliser Triangle, southern Canadian Prairies: description and response to changing climate

by D.S. Lemmen, R.E. Vance, I.A. Campbell, P.P. David, D.J. Pennock, D.J. Sauchyn and S.A. Wolfe. GSC Bulletin 521. \$33.95
(\$44.15 outside Canada)

Living with frozen ground: a field guide to permafrost in Yellowknife, Northwest Territories

edited by S.A. Wolfe. GSC Miscellaneous Report 64. \$15.55 (\$20.20 outside Canada)

To order, see page 40



MARINE GEOSCIENCE

GSC'S MARINE PROGRAM ADDRESSES THE SCIENTIFIC PROBLEMS AND NEEDS FOR GEOSCIENCE INFORMATION ABOUT CANADA'S COASTAL AND OFFSHORE TERRITORIES. THE RESULTING MARINE GEOSCIENCE KNOWLEDGE SUPPORTS GOVERNMENT STRATEGIES AT ALL JURISDICTIONAL LEVELS, HELPS RESOLVE LAND-USE QUESTIONS, AND IS USED BY OIL AND GAS, TELECOMMUNICATION, ENGINEERING AND SURVEY FIRMS FOR A BROAD SPECTRUM OF EXPLORATION AND DEVELOPMENT APPLICATIONS.

Gulf of St. Lawrence

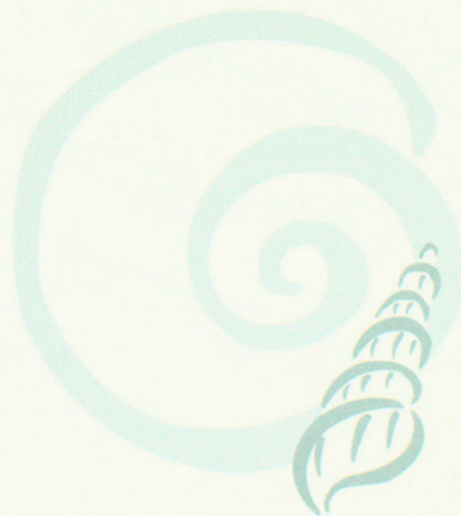
The GSC completed the first year of a three-year effort to examine geological hazards associated with the Maritimes Basin that lies under the Gulf of St. Lawrence. The project, funded by the Panel of Energy Research and Development (PERD), grows from previous multi-year, multi-agency efforts that defined the broad regional crustal and basin framework and the stratigraphic characterization of the basin. One emphasis is on developing an understanding of the history of key reservoir intervals, as this influences petroleum producibility in the basin and is seen by industry as the main geological risk. Reducing reservoir uncertainty will make the Maritimes Basin a more attractive exploration investment opportunity. ⊗

Deep water geoscience: a new frontier

Petroleum industry interest in deep water areas on the Scotian Slope and Grand Banks represents a growing movement from the relatively mature Sable shelf and Jeanne d'Arc Basin developments to a new, mainly uncharted, frontier. It poses unique challenges to both government geoscience research and industry. Knowledge about these areas is sparse, and acquiring the necessary data and knowledge will be expensive and challenging. The knowledge gap is broad, but the GSC is uniquely equipped to cover the spectrum of research required. Recognising this need, the GSC initiated a three-year project to develop the regional surficial framework and to assess geohazards on the continental slope. It has also developed partnerships with industry and other agencies to meet some of these challenges. ⊗

Fraser Delta

A decade-long GSC program of seafloor mapping and sediment sampling in B.C.'s Fraser Delta has had important results that are shaping the course of GSC's future studies in this area. The delta is the product of centuries of sediment build-up from the Fraser River and redistribution by tidal currents. Human activities (confining the river channel, dredging and port development) have altered these natural patterns, and the delta slope is showing signs of localized erosion. Given the Fraser Delta's large population and strategic economic importance, the effect of this erosion on slope instability will be the focus of future GSC research. These studies will be combined with investigations about the impact of rising sea levels. ⊗



Marine data: a valuable resource

THE GSC HAS A WEALTH OF MARINE GEOSCIENTIFIC DATA for the Atlantic, Arctic and Pacific offshore, and it is being used by a growing and diverse set of clients. Over the past year, the GSC continued efforts to make this information more accessible and user-friendly. Two significant initiatives are:

The search for Swissair Flight 111

Within hours of the tragic crash of Swissair Flight 111 on September 2, 1998, GSC staff became an integral part of the disaster response task force. Led by the military, the multi-disciplinary team worked aboard the Canadian Coast Guard vessel MATTHEW. In very rough seas, they operated on a 24-hour basis to identify and map the impact site, produce multibeam bathymetry maps of the crash site, give advice on geology and seafloor environments, and provide information to diving teams and remote observation vessels. Other GSC staff were on the Coast Guard Vessel HUDSON, which was tasked with surveying the crash area with an American high-resolution seafloor scanning system. Still others provided support onshore — ensuring equipment was ready and coordinating activities with other agencies.

GSC's Canadian National Seismograph Network also contributed important information to the investigation into the crash. Two seismograph stations recorded a single impact, and seismologists were able to provide the only precise time of impact (plus or minus one second). The seismic information also provided the basis for an estimate of impact velocity. ☒

- *Expedition Database (ED):* Through multibeam and seismic surveys, the GSC annually acquires many gigabytes of digital data. Added to this are data such as core locations and bottom samples. ED electronically captures all aspects of the data acquisition, archiving, processing, manipulation and interpretation cycle. ED can go to sea allowing data capture at the source. The goal is to achieve paperless cruises and to facilitate sharing of marine data.
- *Canadian Marine Geoscience Information Network (C-Margin):* This project, funded by ResSources GSC, has built smart interfaces that allow users to directly access the data, the metadata, or other marine information and knowledge acquired by the GSC. Constructed using web interface technologies, C-MARGIN employs smart data-mining technologies to deliver the information, data, or knowledge users require as quickly as possible.



GSC (Atlantic)

Changing oil and gas focus on the Grand Banks

With industry priorities in the Jeanne d'Arc Basin shifting from exploration to production, issues related to seabed sediments are influencing GSC research. In response, GSC's seismic reflection coverage was extended east in 1998 into Flemish Pass and across new exploration areas established in recent land sales. The broader and deeper water coverage has led to new inferences about the timing of events on northeast Grand Banks (e.g., age of latest shelf edge glaciation, age of massive "delta" development, age of instability features). The data provides valuable and timely information on geohazards and seabed constraints for industry and regulators who must respectively design and approve safe drilling and development strategies on the Grand Banks. ☒

Labrador Sea-Davis Strait geoscience

Over the past few years, the GSC has kept a watching brief on Labrador Sea and Arctic research, and pursued opportunities to take part in northern geoscience research as they arose.

This year, the GSC signed a research agreement with the Greenland Geological Survey for joint studies of the tectonic evolution of the Northern Labrador Sea-Davis Strait region, which straddles the Canada-Greenland international boundary. This pooling of geoscientific data and expertise from both sides will result in a research program of mutual benefit at a reduced cost. ☒

Seafloor habitat studies

Successful management of Canada's ocean regions requires geoscience information about the seafloor.

The GSC is working with Fisheries and Oceans Canada, the Canadian Hydrographic Service, and the fishing industry to deliver the necessary information for Browns Bank off the East Coast. This area hosts an important scallop industry, and fishing gear damage is a significant problem for scallop draggers. The joint research has produced a series of seafloor maps suitable for fisheries habitat management, the commercial fishery, geological mapping, and navigational charting. Other similar projects are being developed, and these will help make informed decisions about the future use of ocean resources. A new application for GSC's multibeam bathymetric data expertise is habitat mapping in which seafloor geological interpretation is integrated with biological information. ☒

NEW PRODUCTS

Surficial sediments and placer gold on the inner shelf and coast of northeast Newfoundland

by J. Shaw, D. Forbes and K. Edwardson
GSC Bulletin 532. \$41.35
(\$53.75 outside Canada)

Geology and oil and gas possibilities of the Gulf of St. Lawrence

by B.V. Sanford
GSC Open File 3632. \$70
(\$91 outside Canada)

Surficial geology and geomorphology of Gabarus Bay and Louisbourg Harbour, southeast Cape Breton Shelf

by H. Josenhans
GSC Open File 3730. \$45
(\$58.50 outside Canada)

Tectonic assemblages map, Atlantic Region, Canada

by H. Williams and A.C. Grant
GSC Open File 3657 \$15
(\$19.50 outside Canada)

Aerial video surveys: the Bras D'Or Lakes shoreline, Nova Scotia

by R.B. Taylor and D. Frobel
GSC Open File 3656. Various prices,
contact Dave Frobel at (902)426-6867.

Circum-Arctic magnetic map with tectonic overlay

by G. Oakey, R.A. Scott, H.R. Jackson and R. Macnab
GSC Open File 3691. \$15
(\$19.50 outside Canada)

Hydrodynamics and seabed stability observations on Sable Island Bank: a summary of the data for 1996/97

by M. Li, C.L. Amos and D.E. Heffler
GSC Open File 2997. \$20
(\$26 outside Canada)

To order, see page 40

INTERNATIONAL CONNECTIONS

CANADA IS A RECOGNIZED LEADER IN THE GEOSCIENCES, AND THIS EXPERTISE IS MUCH IN DEMAND. GSC'S INTERNATIONAL CONNECTIONS BRING SIGNIFICANT BENEFITS TO BOTH CANADA AND THE PARTNER COUNTRIES. WORK WITH OTHER COUNTRIES TO CARRY OUT GEOSCIENTIFIC RESEARCH OF MUTUAL BENEFIT HAS LED TO ADVANCES IN UNDERSTANDING THE GLOBAL ENVIRONMENT AND OPENED DOORS FOR CANADIAN INDUSTRY. IT ALSO EXPOSES CANADA'S GEOSCIENTISTS TO GEOLOGICAL PHENOMENA THAT MAY HAVE IMPORTANT IMPLICATIONS FOR CANADA IN MINERAL AND PETROLEUM EXPLORATION AND DEVELOPMENT, NATURAL HAZARD ASSESSMENT, AND ENVIRONMENTAL STUDIES.

Brazil project opens doors for Canadian business

A four-year joint program with the Geological Survey of Brazil and the Canadian International Development Agency (CIDA) was completed with the active participation of 11 Canadian companies. The "Canada-Brazil Cooperation Project for Sustainable Development in the Minerals Sector" transferred Canadian technology for geological products and services, enhanced the capability to carry out resource assessment in the Amazon, and established links between Canadian and Brazilian institutions and companies concerned with the sustainable development of Brazil's mineral resources. The economic spin-offs realized by participating Canadian companies is already in excess of \$3 million, with further income anticipated from sale of data. ☉



Steve Evans, GSC

LANDSLIDE HAZARD THREATENS ALGERIAN CITY

A GSC SCIENTIST HELPED ALGERIA'S OFFICE NATIONAL DE LA RECHERCHE GÉOLOGIQUE ET MINIÈRE ASSESS LANDSLIDE HAZARD IN CONSTANTINE, ALGERIA'S THIRD LARGEST CITY. SLOW-MOVING LANDSLIDES ARE WIDESPREAD IN CONSTANTINE, AFFECTING AN ESTIMATED 100,000 PEOPLE AND 15,000 BUILDINGS. URBANIZATION HAS TAKEN PLACE ON MARGINALLY STABLE SLOPES, AND THE SUBSEQUENT MOVEMENTS OF THESE SLOPES HAVE CREATED AN URBAN LANDSLIDE DISASTER OVER THE PAST 25 YEARS. THE POTENTIAL FOR MITIGATING THIS LANDSLIDE PROBLEM IS HIGH, GIVEN THE SLOW-MOVING NATURE OF THE SLOPES. CANADIAN COMPANIES ARE EXPECTED TO BECOME INVOLVED IN THE DESIGN AND CONSTRUCTION OF STABILIZATION MEASURES IN CONSTANTINE.

New earthquake collaboration

Increased understanding of Canada's earthquake hazard can be gained from the study of analogous areas in other parts of the world. The Nankai Subduction zone, off south-west Japan, has striking similarities to the Cascadia Subduction zone on the West Coast. Canada's historical record for that region spans only 100 years, while there is a rich, 500-year written record of earthquakes in Japan. There is also excellent surface exposure in Japan of the source faults. Over the past year, the GSC pulled together partnerships, involving Canada, the U.S and Japan, to develop a mutually beneficial research program that will apply this rich lode of Japanese information to West Coast earthquake studies. ☒

World minerals project

The World Minerals Geoscience Database Project, sponsored in part by industry, is constructing and maintaining digital databases of global geology and mineral deposits. These are suitable for geographic information systems (GIS), summary reporting and cartography. The project builds on GSC's mineral deposits expertise and will aid Canadian companies involved in world-wide exploration for gold, copper, nickel and zinc deposits. Products are now being delivered to project sponsors via an Internet site at www.nrcan.gc.ca/gsc/mrd/wmgdb. The database will also be available to the general public over the Internet. The first products should be available in the year 2000. ☒

GSC part of international team looking at Venice Lagoon

GSC's scientific expertise and unique instrument technology resulted in an invitation to take part in a major international project, funded by the European Community's S&T program and involving many European science institutes. The main thrust is an investigation of the Venice Lagoon to produce a model of the Lagoon that can be used to deal with issues of pollution, water quality, loss of biodiversity, lagoon degradation and channel siltation. The project will provide important input to Canadian issues such as the stability of dredged sediments in Canadian harbours, the siting of aquaculture farms and cost-effective design of offshore engineering structures. It is also providing an international showcase for Canadian technology. ☒

GSC seismographs detect nuclear explosions

The GSC operates a number of its seismograph stations as part of the International Monitoring System that forms part of Canada's obligations in determining compliance with the Comprehensive Nuclear Test Ban Treaty (CTBT). The GSC data is forwarded automatically to the CTBT organization for analysis by the global community. In return, the GSC has access to data from the global monitoring network. In May 1998, days before India or Pakistan announced that they had each carried out five nuclear test explosions, GSC staff were able to confirm that an explosion signal had been detected and provided an initial assessment of weapon explosive yield to disarmament and intelligence agencies within the Government of Canada. GSC's Yellowknife array of 16 seismographs was successful in picking up even the smaller tonnage blasts, demonstrating that it is probably the most sensitive seismic monitoring facility in the world. ☒

Multinational Andean Program (MAP)

This four-year, jointly funded project with the Canadian International Development Agency (CIDA), GSC, and the national geoscience agencies of Argentina, Bolivia, Chile and Peru, is providing a knowledge base for mineral exploration in a remote part of the Andes. Highlights of the past year included:

- An \$800,000 aeromagnetic and radiometric survey flown by a Canadian company over a large area of northeastern Argentina was completed. The project used seed funding from CIDA to leverage further support from ten other companies.
- A broad spectrum of technology sharing, field work and laboratory activities and training took place. Of note were strong connections with GSC's geochronology laboratory and a four-week training course for the GSC-developed software package, *Fieldlog*.
- A Memorandum of Understanding between Chile and Canada was signed on March 14, 1999 emphasizing cooperation in many areas of geoscience between the two countries. ☒

International conferences

The GSC was instrumental in hosting and organizing several important international conferences during the past year:

- As a key sponsor and contributor to the 7th International Conference on Permafrost in Yellowknife, GSC's leading role in permafrost and gas hydrate research was showcased. The conference, with participants from 30 countries, provided an excellent opportunity for GSC to strengthen its national and international linkages. At the meeting, GSC released a guidebook for Yellowknife, *Living with Frozen Ground*, written in close collaboration with the local community and the geotechnical consulting industry. The publication was acclaimed by conference participants, as well as the mayor and community.
- The 5th International Symposium on the Jurassic System took place in Vancouver. GSC scientists were key organizers and led a number of field trips through western Canada. The conference, with delegates from 26 countries, brings together specialists from diverse fields responsible for setting standards for correlations within the Jurassic Period and resolving geological problems by multi-disciplinary approaches.
- GSC glaciologists co-convened the First International Mars Polar Science Exploration Conference in Houston, Texas. This highly successful conference helped to define the goals of a Mars polar mission and ice sampling strategy. ☒

DOING BUSINESS WITH THE GSC

The GSC makes its expertise available to the Canadian geoscience community on a collaborative and cost-recovery basis. In the case of collaborative projects, the GSC works closely with industry partners, sharing costs and expertise on projects of mutual interest. Collaboration can take various forms, for example technology transfer or cooperative research. All information generated by GSC's collaborative programs is made available to the public in a timely fashion.

One of GSC's major goals is to help Canadian resource and environmental companies succeed internationally in today's highly competitive global market. To this end, the GSC can make its unique expertise and facilities available on a cost-recovery basis, where such work does not represent competition with the private sector.

For more information on business opportunities with the GSC, contact:

**Business Development
Earth Sciences Sector
Natural Resources Canada
615 Booth Street
Ottawa, Ontario K1A 0E9
Telephone: (613) 992-8916
Fax: (613) 995-8737
E-mail: dreade@nrca.gc.ca**



INFORMATION

DELIVERY OF GSC'S EXTENSIVE AND DIVERSE SCIENTIFIC OUTPUT IS TAILORED TO CLIENTS' NEEDS FOR INFORMATION IN A VARIETY OF FORMATS, RANGING FROM TRADITIONAL PUBLICATIONS TO THE LATEST IN DIGITAL MAPS. THE GSC IS INCREASINGLY LOOKING TO THE INTERNET AS A PRIMARY MEANS OF COMMUNICATING WITH BOTH ITS TRADITIONAL CLIENTS AND A BROADER PUBLIC. GSC STAFF ARE TRAILBLAZING NEW WAYS OF COMMUNICATING COMPLEX SCIENTIFIC INFORMATION AT A LEVEL ACCESSIBLE AND RELEVANT FOR NON-TECHNICAL USERS, EDUCATORS AND STUDENTS.

GSC website revamped

The GSC launched the latest edition of its website in September. The site has a fresh new look, and the information has been updated and reorganized to allow easier navigation. Added features include a focus on GSC's data resources across Canada, feedback links on each page, corporate plans, and how to make business connections with the GSC. The site is the entry point to GSC's research activities, partnerships, educational materials, as well as to links to other geoscience agencies around the world. The website has evolved into a major vehicle for communicating information to the scientific community and the public at large. ☉

Millionth "hit" on GSC website

One component of the GSC website, that features the work of its terrain sciences group, (<http://sts.gsc.nrcan.gc.ca/>), recorded its millionth "hit" in early 1999 by visitors from 121 countries. This

award-winning site, which averages 20,000 "hits" every week, covers a wide range of GSC research: gas hydrates, environmental geology, geohazards, glaciology, permafrost, hydrogeology, mineral exploration, surficial mapping, urban geology, and NATMAP. One of its most popular features is a photo archive of landscapes of Canada. ☉

Award-winning educational website

With funding from the Quebec government, the GSC developed *If the Earth could talk ... An introduction to the earth sciences*, a website that presents geoscience information in a lively, non-technical manner for the public. The site has been the recipient of many awards for excellence. It was awarded four stars by *Hachette junior* and five stars by *Guide-Internet* magazine. It also received a special mention in the French magazine *Point.net* and from the *Centre international pour le développement de l'inforoute en français*. <http://www.inrs.quebec.ca/cgq/terre>. ☉

Lessons from GSC's first Internet map release

In 1996, the GSC for the first time released a geological map, *Surficial Materials of Canada*, via the Internet (<http://sts.gsc.nrcan.gc.ca/page1/sgm/maps.htm>), and to date, about 700 digital copies have been downloaded. The Internet release was designed as a learning experience for the GSC, and it has helped improve service to clients. In order to download the map, clients first completed a questionnaire that helped the GSC pinpoint client needs and find solutions to their problems. It also provided the GSC with valuable client profile information: they came from 20 countries and fell into four groups: private sector (40%), university (28%), governments (20%), and other (12%). Business opportunities have grown out of the client feedback, for example, a royalty agreement was signed for the use of the map in earthquake risk analysis software. ☉

CORDLink: geoscience for the Canadian Cordillera online

A team of geoscientists and web experts from the GSC, B.C. Geological Survey and University of British Columbia have created an exciting Internet-based digital geoscience library that seamlessly integrates maps, images and text on the geology of the Canadian Cordillera. **CORDLink**, part of the ResSources GSC initiative, is suitable a wide range of users, including professional geoscientists, students and educators. ☒

GSC, a partner in GEOIDE

Geomatics for Informed Decisions (GEOIDE) was launched at Laval University on October 15, 1998, GEOIDE is a national network of centres of excellence in geomatics funded and managed by Canada's three granting councils and Industry Canada. Its objectives are to support the development of Canadian expertise in geomatics and the growth of geomatics as a strong Canadian industry. A major focus will be the training of new researchers in this rapidly expanding field. The GSC will sit on the GEOID Board of Directors as one of ten partners in the network, and it will play a major role in two multi-disciplinary earth sciences projects. ☒

GSC SCIENTISTS JOHN CLAGUE AND BOB TURNER AND THE GEOSCAPE VANCOUVER POSTER THAT GREW TO INCLUDE A SERIES OF THEMATIC POSTERS AND ONLINE RESOURCES, AND STIMULATED NINE OTHER PROJECTS IN COMMUNITIES ACROSS CANADA.



Spreading the news: contributing to public awareness of science

A COMMITMENT TO INCREASING PUBLIC AWARENESS of science is a longstanding cornerstone of GSC's corporate culture. Outreach activities, whether at the national or community level, are carried out with enthusiasm and innovation by GSC staff. GSC initiatives, designed for one part of the country, are often used as a model for similar activities in other communities. Some examples, out of many, include:

- *The Calgary Science Network, initiated and supported by GSC scientists has, over the last decade, spawned similar organizations in cities world-wide, and in particular contributes to a well-organized provincial network in support of the Alberta education system. The Network was a Michael Smith Award for Science Promotion winner in 1994. http://www.cadvision.com/calg_sci_net/*
- *The GSC, in conjunction with several professional geoscience associations and ResSources GSC, is spearheading **EarthNet**, an exciting website that is a gateway to earth science education tools. It provides teachers with activities and resources for use in the classroom, a searchable database, a glossary of earth science terms, an online forum and chat room, and much more. <http://agc.bio.ns.ca/EarthNet>*
- *Geoscape Vancouver, the brainchild of two GSC scientists, is a colourful series of posters and online materials that explain the key earth science issues relevant to that community. This initiative has received rave reviews from educators and has sparked similar projects for other communities across the country. So far, there are nine Geoscape projects underway: in Whitehorse, Victoria, Calgary, southern Saskatchewan, Winnipeg, Toronto, Ottawa, Québec and Halifax.*

<http://sts.gsc.nrcan.gc.ca/urban.htm>

Geology and Inuit art connect

Increasing interest in the nature of carving stone materials resulted in new connections for the GSC. In the past year, GSC scientists held a workshop on the geology of carving stone for the Inuit Art Foundation, so that they could respond to growing customer interest in the type of stone used in carvings. GSC also helped the McMichael Collection of Art develop a new exhibit of Inuit sculpture. GSC contributed information and exhibit materials to illustrate the geology of carving stone and the role of geoscience in the search for new sources of carving stone. The exhibition will run from May-September 1999 in Kleinberg, Ontario. This connection provides an excellent opportunity to demonstrate a unique link between geoscience and art, while at the same time increasing broader public awareness of geology and the GSC. ☒



VISITORS TO THE OPEN HOUSE AT GSC'S SIDNEY OFFICE VIEW SEISMOGRAPH RECORDING DRUMS, PART OF THE CANADIAN NATIONAL SEISMIC NETWORK.

M. Schmidt, GSC

Coast-to-coast connections with youth

GSC science was front and centre at open houses across the country. The public attended in the thousands, and most brought their young children. Associated student programs connected tomorrow's geoscientists with today's.

- The celebration of the 30th anniversary of GSC's *Geomagnetic Laboratory* culminated, May 2, with a public open house in Ottawa which drew about 1,000 visitors.
- The *Institute of Ocean Sciences*, which houses Fisheries and Oceans and GSC, at Sidney, B.C., opened its doors, October 1-4. Attendance topped 6,000 visitors, and about 2,000 students were treated to lectures on marine geoscience, seismology and geodynamics.
- The GSC played a leading role in the Ottawa celebration of National Science and Technology Week. The *Science Funfest*, October 18, had 1,300 visitors, and a week-long program of workshops connected 400 students with GSC scientists.
- The Open House at the *Bedford Institute of Oceanography* in Dartmouth, N.S., where the GSC is co-located with several other government agencies, was a resounding success. School Day, October 22, provided tours for about 1,500 students and their teachers. More than 25,000 people visited during the public Open House, October 24-25.

GSC staff put a tremendous amount of energy and volunteer time into these events, but their efforts were well rewarded by the enthusiasm, interest and support that the public showed for their science. ☒

Digital geology map of Yukon

An exciting new initiative to produce the first comprehensive bedrock geology map of the entire Yukon is nearing completion, with a digital compilation at 1:500,000 scale on CD-ROM and a wall-map at 1:1,000,000 scale scheduled for release in the fall of 1999. The project, which grew from needs expressed by mineral explorationists, was funded by the Yukon Geology Program and DIAND, and carried out by a team of their geologists and GSC GIS experts. The CD-ROM will also include geochronology, paleontology, mineral deposits and surficial geology data sets, making it a valuable tool for resource assessment, exploration and land-use decisions. The wall-map will be an excellent educational resource and valuable for regional scientific and exploration program planning. ☒

Lecture tours highlight GSC research

Three GSC scientists were recognized by the geoscience community this year for the excellence of their research and their ability to communicate its impact to a broad audience.

- Marc St-Onge was the Geological Association of Canada's 1999 Howard Street Robinson guest lecturer. This honour is awarded annually to a prominent Canadian geoscientist for the "furtherance of scientific study of Precambrian geology and metal mining". Dr. St-Onge, during a four-week national tour, gave lectures at 21 Canadian universities and institutions.

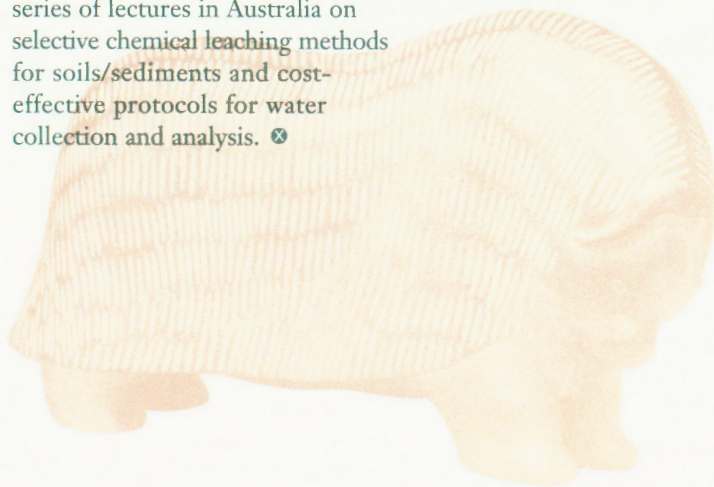


GSC (Pacific)

100 YEARS OF EARTHQUAKE STUDIES ON THE WEST COAST

THE GSC CELEBRATED THE 100TH ANNIVERSARY OF ITS SEISMIC OBSERVATORY ON OCTOBER 22, 1998, MAKING IT ONE OF THE WORLD'S OLDEST EARTHQUAKE OBSERVATORIES. THE ORIGINAL SEISMOGRAPH, WHICH WAS INSTALLED IN VICTORIA IN THE FALL OF 1898, HAS BEEN RESTORED AND IS ON DISPLAY IN THE SIDNEY OFFICE.

- Harvey Thorleifson was one of the 1998-99 Canadian Institute of Mining, Metallurgy, and Petroleum Distinguished Lecturers. Dr. Thorleifson toured Canada giving his talk *The Search for Diamonds in Canada* on the history, science, and technology of diamond exploration in Canada. As well as talks at professional events, he presented 14 public lectures.
- Gwendy Hall, as the 1998-99 International Association of Exploration Geochemists' Distinguished Lecturer, gave a series of lectures in Australia on selective chemical leaching methods for soils/sediments and cost-effective protocols for water collection and analysis. ☒



THE CGKN

THE CANADIAN GEOSCIENCE
KNOWLEDGE NETWORK**A STRATEGIC INITIATIVE TO
PUT GEOSCIENCE KNOWLEDGE
ABOUT CANADA'S LANDMASS
AND OFFSHORE REGIONS ONLINE.**

The Canadian Geoscience Knowledge Network is a partnership project of the GSC and provincial and territorial government geoscience agencies. Slated for completion in 2010, the Network will provide Internet access to the information and data holdings of all government geological surveys in Canada. Connections to geoscience information from academia, other government agencies, and industry are under discussion to make the Network truly national.

The Network's "single window" access to geoscience information and expertise is essential to maintaining Canada's position as a world leader in providing geoscience information for sustainable resource development, and it will enhance Canada's competitive position in the global geoscience and resource exploration community.

ResSources GSC, the program that will deliver GSC's component of the Network, is GSC's flagship knowledge project. ResSource's GSC will complement the Canadian Geospatial Data Infrastructure (CGDI) and other information highway initiatives underway in Geomatics Canada. It will also form an important component of the Natural Resource Knowledge Networks being developed with other federal and provincial government departments and agencies.

In early 1998, the GSC, in collaboration with GeoConnections, initiated the Geoscience Knowledge Network project to demonstrate and evaluate Internet access and distribution of its geoscience knowledge in a client-focused manner. The project was renamed ResSources GSC in March 1999 to align it with other similar initiatives underway at NRCAN and to avoid confusion with external initiatives with similar names.

In its first year of operation, ResSources GSC supported the development of a range of demonstration projects. These projects present innovative approaches for delivering diverse GSC data and knowledge on the Internet.

VISIT RESSOURCES GSC:
[HTTP://RGSC.NRCAN.GC.CA](http://rgsc.nrcan.gc.ca)

RESSOURCES GSC

- **CORDLINK:** a digital geoscience library for the Canadian Cordillera.
- **EARTHNET:** a virtual resource centre for earth science materials suitable for use in the classroom.
- **MIRAGE:** a digital image library of GSC maps.
- **C-MARGIN:** marine geoscience knowledge from the Atlantic, Pacific and Arctic oceans and the Great Lakes.
- **BATHURST EXTECH-II DATABASE:** an integrated multidisciplinary geoscience database for New Brunswick's Bathurst mining camp.
- **EARTH SCIENCE VIEWER:** an interactive map and drill hole query system for urban geology studies.
- **CANADIAN CHRONOLOGICAL DATABASE:** a national web repository for geochronological information.
- **CANADIAN GEOPHYSICAL ATLAS ONLINE:** a web-enabled geophysical atlas including geomagnetic, gravity, seismic and topographic data.
- **NATMAP SHIELD MARGIN PROJECT:** a multidimensional database for the Shield Margin/Lithoprobe Trans-Hudson Orogen project area.
- **INTERACTIVE MAP QUERY SYSTEM:** a map-based system of surficial geology, geochemistry and mineral deposit data for Canada.



PRODUCTS AND SERVICES

Earth Sciences Information Centre (ESIC)

ESIC has Canada's largest collection of books, journals and maps on the earth sciences with world-wide coverage. Its collections also include CD-ROMs, all GSC publications, videos, atlases, audiotapes, and photographs.

Many of ESIC's products and services are available through the Internet where clients have access to the Library Catalogue, the federal geoscience database GEOSCAN, reference services and document delivery.

The Library Catalogue has information on the status and location of the more than 2,000,000 holdings of ESIC and GSC's regional libraries. GEOSCAN, a searchable database of GSC publications, has over 40,000 bibliographic records concerning the Canadian landmass and offshore regions.

Enquiries can be sent via the ESIC website, e-mailed to ESIC@NRCan.gc.ca, faxed to (613) 943-1549, or contact the Information Desk at (613) 995-4071. Document delivery requests should be sent to ESIC.ILL@NRCan.gc.ca. Some fees for document delivery and reference services may apply.

Visit ESIC online at
www.nrcan.gc.ca/less/esic.

Coordinates for GSC's regional libraries:
Calgary Tel.: (403) 292-7165;
E-mail: calgary.ref@gsc.nrcan.gc.ca
Québec Tel.: (418) 654-2677;
E-mail: dupuis@gsc.nrcan.gc.ca
Vancouver Tel.: (604) 666-3812;
E-mail: libvan@gsc.nrcan.gc.ca

Aeromagnetic and gravity data

Aeromagnetic, gravity and digital elevation data for Canada are available as colour plots or digital data. These national data sets can be scaled to any size, provided in most formats and supplied on a variety of media types including delivery via FTP. Products range from economically priced, generic coverage to customized, project-specific data sets. Quotes are available on request or visit our web site for product and pricing details.

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Web site:
<http://gdcinfo.agg.nrcan.gc.ca/cat/>

Crustal-scale expertise

The GSC provides instrumentation and expertise for crustal scale seismological and electromagnetic studies. In recent years this has involved international projects led by academia, industry or governments abroad, on a cost-recovery basis. Focus is on two areas:

Seismic refraction: The GSC has 234 recorders and field service units (computers) that employ GSC-developed Lithoseis software, along with field expertise in designing and conducting refraction experiments, and substantial experience and expertise in data processing and interpretation.

Electromagnetics: The GSC has two high-frequency magnetotelluric systems and 16 long-period magnetotelluric recording units (LIMS), as well as display and processing software and data acquisition, processing, modelling and interpretation expertise.

Crustal Geophysics
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HOW TO ORDER GSC PRODUCTS

The GSC publishes its research in many scientific journals and commercial publications. It also has a publishing capability, and all its products, both print and digital, are sold through the GSC Bookstore.

Publications and CD products may be ordered from the GSC Bookstore in Ottawa or from our sales outlets in Sainte-Foy, Calgary and Vancouver (see back cover for contact numbers).

GSC's scientific publishing website at www.nrcan.gc.ca/gsc/gicd/pubs/publish.html provides online ordering as well as the GSC Information Circular that announces the release of new reports, maps and open files.

For all ordering options, prepayment is required by cheque or money order made out to the Receiver General of Canada. VISA and Mastercard are accepted. Applicable taxes and shipping and handling costs are extra.

Core and sample repository

This facility houses cores, drill cuttings and associated documents for all wells drilled on Canada Lands north of 60° and in the offshore regions of the west and east coasts. Cuttings from oil and gas wells in the Prairie provinces and British Columbia also are available. There are 14 examination booths and seven core tables available for use by clients. Repository staff retrieve material for examination and sampling as requested. The sampling of cores and unwashed cuttings is permitted under strict guidelines, and any resulting thin sections, slides or analytical data must be returned at the end of the loan period.

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Marine equipment rental

The GSC has unique marine equipment which is available for use by external partners under certain arrangements. International requests for scientific collaboration often involve use of this specialized equipment. The GSC can make the equipment available, under agreement, to industry to enable them to tender on a contract or to be a sub-contractor on a GSC-initiated project.

For example, the GSC made its ocean bottom seismometers available to a Canadian company to enable it to bid on a contract with the British Antarctic Survey to conduct surveys in the South Atlantic.

To explore possibilities, contact:

R. Pickrill
Telephone: (902) 426-3587
Fax: (902) 426-4104

R. Currie
Telephone: (250) 363-6419
Fax: (250) 363-6565

LABORATORIES

Analytical chemistry laboratories

These laboratories specialize in the total analysis of geological and environmental samples for most elements of the periodic table. They are equipped with state-of-the-art equipment including laser ablation and electrothermal vaporization ICP mass spectrometry. Extremely small samples can be analysed for trace elements and for isotope ratios of certain elements such as boron, lithium, lead and osmium. Chelation ion chromatography coupled with plasma spectrochemical techniques allows for the analysis of pore fluids and brines, as well as ultra-trace analysis of geological materials. The laboratories collaborate with industry and universities on method and instrument development projects, and offer training in instrumental technology and applications to geochemical analysis.

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Analytical method development laboratory

This laboratory focusses on speciation of elements in sediments, soils and waters; cost-effective methods to analyse surface waters to ppb, ppt and ppq levels by ICP-MS and ICP-AES; and methods by which to differentiate geogenic and anthropogenic sources of metals. This state-of-the-art laboratory includes a Class-100 Cleanroom.

New methods are designed and tested mainly through collaborative projects in environmental and exploration geochemistry with scientists in the GSC, elsewhere in Canada and abroad in other government, university and industry institutions. The methodology is developed and transferred to Canadian commercial geochemical and environmental laboratories through collaborative learning, training and international publications.

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Delta-Lab

The GSC-Québec isotopic geochemistry laboratory analyses stable isotopes of hydrogen, carbon, nitrogen, oxygen and sulphur using PRISM-III, SIRA-12, GC-COMBUSTION-Prism-III (GC-IRMS), continuous elemental analyser with Prism-III (EA-CF-IRMS), auto-water for oxygen, and elemental analyser and extraction lines for water, carbonates, sulphides, sulphates and organic matter. With this equipment, the laboratory can cover the entire range of stable isotopic tracers applied to hydrogeological, environmental, metallogenic, diagenetic and sedimentological studies by analysing the isotopes of water, reagent hosts and dissolved components.

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Fax: (418) 654-2615
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Dendrochronology and dendrogeochemistry laboratory

These facilities help scientists to analyse tree growth and use trees as bio-indicators of natural and anthropogenic environmental disruptions. Tree growth parameters are analysed by means of a high-precision (0.001 mm) Unislide Velmex micrometer, connected to a Metronics Inc. QC-1000 data-acquisition system, which is used to transfer and digitally process data. Dendrochronology can be combined with geochemical analysis of growth rings to document the nature of environmental conditions as well as their spatial and temporal evolution. Applications related to climate change, environmental geodynamics and environmental geochemistry may be developed.

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Gamma-ray spectrometry laboratory

This laboratory analyses geological and environmental samples to measure absolute radio-element concentrations of potassium (%), equivalent uranium (ppm), and equivalent thorium (ppm). The spectrometer utilises two, lead-shielded, 14 cm by 14 cm sodium iodide detectors. A GSC-designed software package processes data acquired by the detectors and records gamma-ray spectra from successive samples. Calibration of the spectrometer is accomplished using potassium (RGK-1), equivalent

uranium (RGU-1), and equivalent thorium (RGTh-1) standards recognised by the International Atomic Energy Agency. Laboratory services are available on a cost-recovery basis.

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Geochronology laboratory

This laboratory specializes in rock and mineral age dating and isotopic microanalysis using U-Pb, Sm-Nd, Rb-Sr, and Ar-Ar isotopic systems. It has long been involved in developing age-dating techniques to resolve important questions in geological mapping and the timing of tectonic and mineralizing events. Different chronometers are closely integrated to provide optimal approaches for answering an ever-expanding range of geoscience questions. Advice from laboratory staff and use of its facilities are available to clients in Canada and abroad.

A recent addition to the laboratory is the Sensitive High Resolution Ion Microprobe (SHRIMP). One of only a half dozen in the world, the instrument allows unprecedented insights into the genesis and history of single mineral grains and rocks. From such information, an enhanced understanding of fundamental and practical processes can be addressed.

The latest acquisition is a new, state-of-the-art automated CO₂ laser for analysis of single to multi-grain samples in the Ar-Ar laboratory. This laser extends GSC's microanalytical capability to the Ar-Ar geochronological system, providing for a unique breadth that allows for the study of samples ranging in age from historical time to the oldest rocks on earth.

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Geocryology research laboratory

GSC and Carleton University have established the Geocryology Laboratory at the university to facilitate joint research and to ensure adequate training for scientists and students in the field of permafrost research. GSC contributions to the facility include: high precision thermal calibration equipment, a needle probe thermal conductivity measurement system, a cold room, and miscellaneous equipment suitable for experimental work and field studies. This comprehensive research-oriented laboratory can support fundamental and applied research.

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Geomagnetic laboratory

This laboratory develops, tests and calibrates geophysical instruments for several GSC activities: geomagnetism, marine geophysics, crustal geophysics and seismology. For external clients, it calibrates magnetometers, magnetic compasses, and magnetotelluric systems. Operational and scientific groups collect and use geomagnetic data from across Canada for a variety of purposes, including the production of magnetic charts for navigation by compass and magnetic storm warnings. Scientific and engineering collaborations with industrial and academic partners are welcomed. Research specialities include the effects of magnetic storms and other related phenomena on modern technological systems such as electric power transmission and pipelines.

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Light stable isotope (LSI) laboratory

This laboratory specializes in the application of oxygen, hydrogen, sulphur and carbon isotope geochemistry to the study of hydrologic, petrologic, and ore-forming processes. A complete range of inorganic and organic Earth materials are analysed as macro and micro samples, using state-of-the-art and, in some cases, world-leading techniques, including laser-based fluorination of microscopic samples. It is involved in many activities, including a government-industry project to document paleohydrothermal systems and alteration associated with volcanic-associated massive sulphide deposits, the

GSC-led Sullivan Project, and a recalibration of the internationally accepted scale for sulphur isotope geochemistry. Collaborating scientists from government, industry and university work closely with laboratory personnel. Where appropriate, collaborators may carry out analytical procedures themselves, or rely on support from laboratory staff, on a cost-sharing basis.

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Microanalysis facility

This laboratory's principal function is the imaging and chemical analysis of geological materials such as microfossils and of sediment/mineral grains. The facility houses an Environmental Scanning Electron Microscope (ESEM) with attached energy dispersive spectrometer, an X-ray diffractometer, and an optical image analysis system. It is capable of examining unconsolidated marine sediment samples in a natural (wet) state for more accurate characterization of geotechnical properties such as porosity. A recent upgrade to the ESEM allows for the quantitative analysis of sulphides and silicate minerals. The facility collaborates with outside users in a variety of ongoing projects in geological, environmental, and biological studies, and is open to new research initiatives.

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Micropaleontology laboratory

This laboratory specializes in microfossil (conodonts and radiolarians) processing and extraction. Facilities include a scanning electron microscope and energy dispersive spectrometer. The laboratory collaborates with governments, industry and universities. Where appropriate, collaborators may work individually or supported by laboratory staff on a cost-sharing basis.

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Mineralogical laboratories

GSC's Mineralogical Laboratories are equipped to conduct physical, optical, chemical and crystallographic analysis of minerals utilizing electron-microprobe, scanning-electron microscope, and x-ray diffraction techniques. In addition to their own research, the highly qualified professional staff provide mineral analysis to the other programs of the GSC and also provide expertise and training to the scientific community.

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Organic geochemistry laboratory

This laboratory is equipped to perform organic geochemical analyses of oils, coals and sediments and some types of environmental analyses. Data from these analyses can be used for assessing the organic carbon content, petroleum generation potential, maturity and paleoenvironment of deposition of sediments, oil-oil and oil-source correlations, maturity and degree of biodegradation, direction and relative distance of migration of hydrocarbons, the simulation (using pyrolysis techniques) and kinetics of oil and gas generation from sediments and coals, and the type and origin of hydrocarbon contamination in sediments. The laboratory provides organic geochemical analyses on a cost per sample basis.

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Organic petrology laboratory

This laboratory is equipped with a range of microscopes, including standard petrological microscopes for determining thermal maturity (including vitrinite reflectance and fluorescence) and organic facies, for interpreting the origin of pyrobitumens, for measuring homogenization temperatures, and for investigating hydrocarbon fluid inclusions. An image analysis system for automated optical microscopy (e.g., particle size and shape analysis), a confocal scanning microscope for 3-D imaging (e.g., micropaleontological applications) and a scanning electron microscope are also available.

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Paleomagnetic laboratory

This well-equipped laboratory specializes in Quaternary magnetostratigraphic correlations, tracking large scale ancient fluid-flow events, Cordilleran tectonic displacements and structural rotation problems. Most of the work done in the lab is collaborative with partners from universities and government covering the costs of sample preparation (performed on site) and measurement.

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Paleontology services

GSC paleontologists and laboratory facilities are available nationally and for a variety of cost-recovery and collaborative activities. These include fossil identifications and interpretations, laboratory preparations, referrals of paleontological samples and tasks to specialists, contributions to regional stratigraphic studies, short courses and training (in-house and external), needs analysis, and advice on setting up laboratories and other facilities. Available expertise is increasingly being concentrated on microfossils (primarily conodonts and foraminifera) and palynomorphs.

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Palynology laboratory

This laboratory specializes in the analysis of rock and sediment samples for palynological and other research. Principal techniques include the breakdown of rocks and sediments using hydrochloric and hydrofluoric acid to produce organic residues, and the use of heavy liquid and sieving techniques to concentrate palynomorphs (fossil spores, pollen, dinoflagellates, etc.) within the residues. Material from different geological ages requires different treatments, and this laboratory has the expertise and equipment to work with material from the entire range of geological ages. It is the only facility of its kind in the Maritimes.

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Radiocarbon (¹⁴C) dating laboratory

The ¹⁴C laboratory provides dating control for many of GSC's surficial mapping and environmental projects. As well, the lab sets national standards and maintains a Canadian ¹⁴C database that may be consulted by Canadian or other researchers. Part of the database is now available online at the ResSources GSC website: www.rgsc.nrcan.gc.ca/e/projects (click on Canadian Chronological Databases). The laboratory will consider providing dating control for university researchers on a case by case basis at a cost per sample.

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Sedimentology laboratory

This laboratory provides analysis of unconsolidated sediments. A number of tests are available to GSC scientists, including Atterberg limits, grain size (sieving, particle size analyser, or settlement column) and carbon content. The laboratory allows the GSC to explore non-standard processing techniques and to customize analysis for given GSC projects. The laboratory will consider providing specialized (i.e. non-commercially available) sedimentological analysis to university or other stakeholders on a cost per sample basis.

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Unconsolidated marine sediment laboratory

This laboratory provides access to several user-friendly facilities to measure the physical and visual properties of unconsolidated marine sediments. A state-of-the-art multisensor track utilizes a Cesium 137 source to digitally measure sound velocity, shear strength and water content as well as other physical properties of whole round cores (not split) along their entire length. Additional physical measurements can be taken with an Image x-radiograph system that can orient the whole core and record the information. Once cores have been split, a camera can easily capture the core face colours before oxidation commences, against photographic standards for future archival reference. External researchers are welcomed.

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FINANCES

EARTH SCIENCES SECTOR 1998-1999 EXPENDITURES (\$'000's)

GEOLOGICAL SURVEY OF CANADA

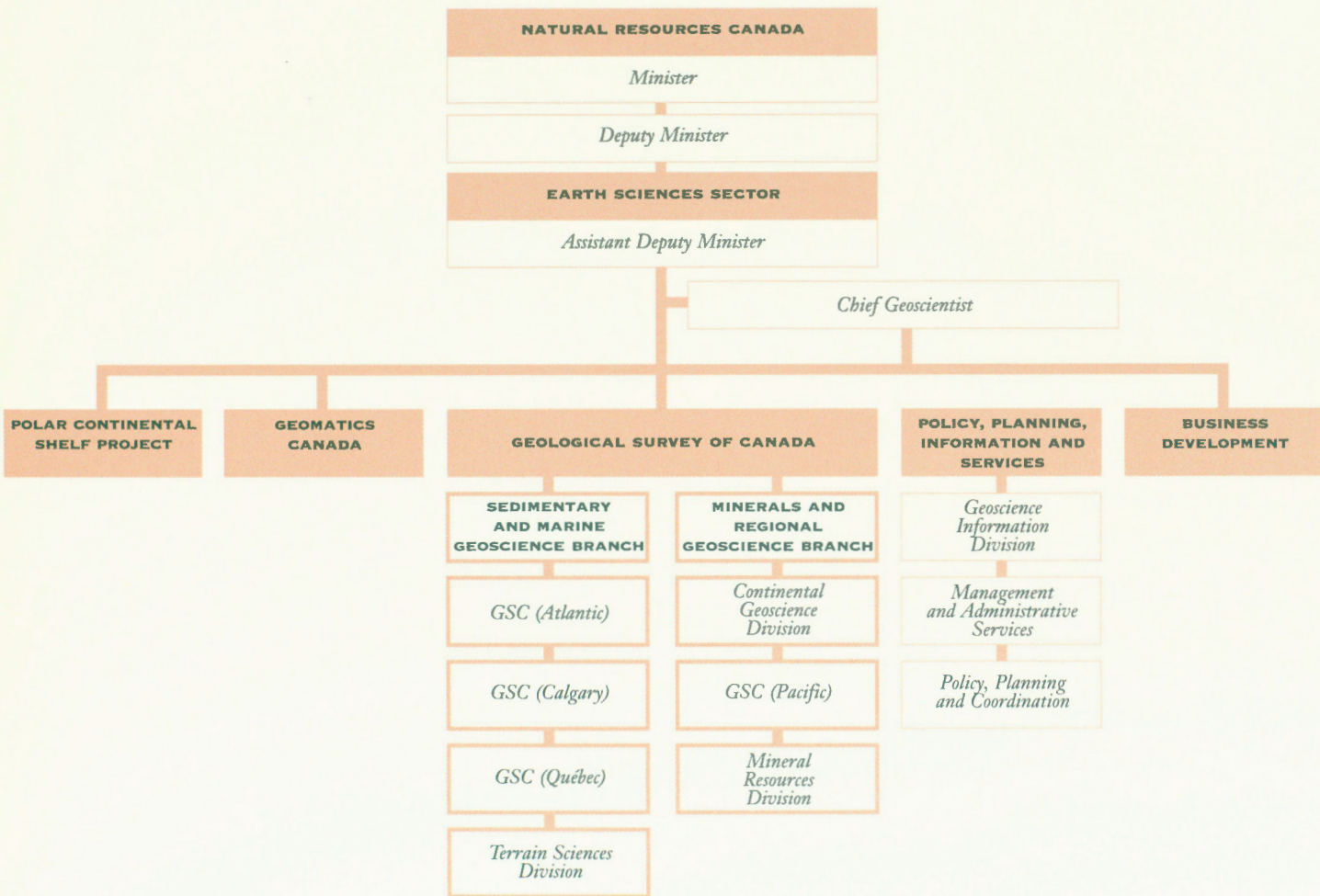
MINERALS AND REGIONAL GEOSCIENCE BRANCH	SALARY	OPERATING	CAPITAL	TOTAL	REVENUE,* COST SHARING
Director General	225	80	0	305	1
Continental Geoscience	5,456	3,198	859	9,513	1,123
GSC Pacific (Ottawa)	2,042	1,391	1,333	4,766	201
GSC Pacific (Sidney)	2,028	1,126	512	3,666	269
GSC Pacific (Vancouver)	1,607	816	171	2,594	1,071
Mineral Resources	5,595	1,723	892	8,210	1,202
<i>Total</i>	<i>16,953</i>	<i>8,334</i>	<i>3,767</i>	<i>29,054</i>	<i>3,866</i>
SEDIMENTARY AND MARINE GEOSCIENCE BRANCH					
Director General	200	55	10	265	0
GSC Atlantic	5,138	2,693	657	8,448	934
GSC Calgary	5,447	3,587	829	9,863	921
GSC Québec	1,505	1,462	221	3,188	147
Terrain Sciences	4,323	2,554	397	7,274	872
<i>Total</i>	<i>16,613</i>	<i>10,351</i>	<i>2,114</i>	<i>29,078</i>	<i>2,873</i>
<i>TOTAL GSC</i>	<i>33,566</i>	<i>18,351</i>	<i>5,881</i>	<i>58,132</i>	<i>6,740</i>
GEOMATICS CANADA	27,968	25,437	4,636	58,041	34,568
POLAR CONTINENTAL SHELF PROJECT	643	2,352	93	3,088	2,441
CORPORATE SERVICES**					
Executive Services***	1,967	1,231	82	3,280	91
Policy, Planning, Information and Services Grants and Contributions	8,221	5,207	1,431	14,859	368
				1,697	
<i>Total Corporate Services</i>	<i>10,188</i>	<i>6,438</i>	<i>1,513</i>	<i>19,836</i>	<i>459</i>
<i>TOTAL SECTOR</i>	<i>72,365</i>	<i>52,912</i>	<i>12,123</i>	<i>139,097</i>	<i>44,208</i>

* Includes additional funds from intellectual property, vote-netted revenue, revolving fund, specified purpose accounts, and transfers from other government departments.

** Provides support to the Geological Survey of Canada, Geomatics Canada and the Polar Continental Shelf Project.

*** Includes Business Development Office.

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