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# Geological Survey of Canada

1996



1997

**RESERVE/RÉSERVÉ**

NOT TO BE TAKEN FROM THE ROOM  
POUR LA CONSULTATION SUR PLACE



Natural Resources  
Canada

Ressources naturelles  
Canada

Canada

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ON THE COVER

## The Saguenay flood

On July 19 and 20, 1996, an extreme storm brought heavy rainfall to the Saguenay-Lac-Saint-Jean region of Quebec. Runoff caused rivers to rise dramatically to flood levels, in some cases producing discharges well in excess of previously recorded maximum flows. The flooding had severe effects along the valleys: homes were inundated, damaged or destroyed; dams were overtopped and damaged; reservoirs were drained; bridges and roads were washed out; and extensive bank and floodplain erosion occurred. Overall, more than 14,500 people were temporarily evacuated, 2,000 people were left homeless, and two people were killed.


Due to the urgent requirement for geological and geotechnical information, a GSC team was dispatched to the area to provide scientific advice, to evaluate the geomorphic effects and secondary hazards associated with the flood, and to make recommendations for future work. Funding was provided by Emergency Preparedness Canada.

The GSC also collaborated with *INRS-Géoressources* to produce an inventory of the landslides that followed the heavy rains. This will help the provincial authorities determine the conditions that trigger landslides and redefine zoning parameters.

*Cover photos: Rivière aux Sables. Credit: Christian Bégin*

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# A Message from the Minister



**THE HONOURABLE  
RALPH GOODALE**

Minister of  
Natural Resources  
Canada

In 1842, twenty-five years before Confederation, the Government of Upper and Lower Canada set up the Geological Survey of Canada (GSC). Its mission was to provide a comprehensive picture of the mineral wealth of this new land – information fundamental to the development and economic growth of any nation.

Today, as an important part of Natural Resources Canada, the GSC continues to increase our knowledge about Canada's resource potential. This work is as vital as ever to the development of new jobs and economic growth, particularly in rural and remote regions. Innovative research and technology programs help to stimulate the growth of Canada's mineral exploration and mining industries, as well as the oil and gas industry. An excellent example of this effort is the GSC's role in the discovery of new oil deposits off the coast of western Newfoundland. This is expected to spark new petroleum development activity and complement activity off the East Coast that is being spearheaded by the Hibernia project.

Over the years, the GSC's focus has expanded to include research on natural hazards, such as earthquakes and landslides. In addition, through portraits of climatic conditions on our planet dating back hundreds and thousands of years, GSC research is increasing our understanding about the potential impact of global warming. This work provides an essential perspective to the international climate change debate.

In the past year, the signing of the Intergovernmental Geoscience Accord emphasized the importance of a partnership approach to collecting and sharing geographic information about Canada. Progress in establishing bilateral agreements with territorial and provincial geological surveys is building a stronger foundation for cooperation across the country. This partnership effort will be critical to our success in developing a geoscience data infrastructure that will be available to all Canadians on the information highway.

Looking to the future, Canada's international reputation for geoscience excellence will depend on attracting Canadian youth to careers in the earth sciences. The many outreach programs at GSC facilities across the country are but one example of the dedication of committed staff that will support Canada as we move into the next millennium.

A handwritten signature in black ink, appearing to read 'Ralph Goodale', written in a cursive style.

Ralph Goodale

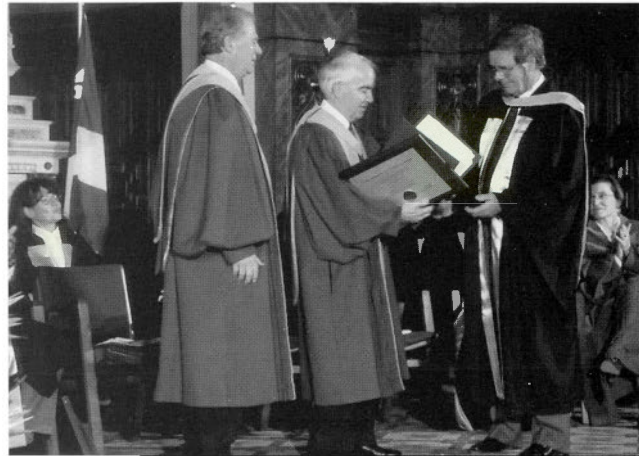
## FIVE YEAR STRATEGIC PLAN FOR GEOSCIENCE

The GSC released the blueprint that will guide its work for the next five years. The Strategic Plan for Geoscience 1996-2001 addresses Canada's future requirements for traditional geoscientific information, as well as the need for new types of knowledge, new ways of delivering this knowledge to our clients, and new ways to support increasing employment and an expanding economy – all in an environmentally responsible way

Partnerships are the foundation of the strategic plan. Meeting Canada's geoscience needs is increasingly a shared responsibility with provincial, university and industry partners. The plan defines the terms under which the GSC will operate with its various partners, and gives a broad-brush version of GSC's proposed program directions for the next five years.

The plan is the result of extensive consultation, both in-house and externally. For a copy, contact:

Communications Office  
Geological Survey of Canada  
Room 244, 601 Booth Street  
Ottawa, Ontario  
K1A 0E8



D.C. FINDLAY, RECEIVING AN HONORARY DOCTORATE FROM THE INSTITUT NATIONAL DE LA RECHERCHE SCIENTIFIQUE (INRS)

On December 6, 1996, D.C. Findlay, a former GSC senior manager, received an honorary doctorate from the Institut national de la recherche scientifique in recognition of his pioneering role and outstanding leadership in building partnerships, stimulating collaboration and promoting the value of geoscientific research. Alain Soucy, Director General of INRS, and Claude Hamel, then President of the University of Quebec, made the presentation to Dr. Findlay.





**GEOSCIENCE SURVEYS PROVIDE** the national geoscience knowledge framework for Canada's landmass. Geoscience maps and associated knowledge underpin all private and public sector activities related to the sustainable development of Canada's onshore mineral, energy, water and other resources, land-use decision making, and public health and safety linked to natural hazards.

Bedrock and surficial geoscience mapping are fundamental elements of this work. They are done in partnership with provincial and territorial geoscience agencies and integrated with thematic or process-oriented studies of the architecture and history of the landmass. GSC's National Geoscience Mapping Program (NATMAP), a partnership with provincial and territorial agencies, is a key mechanism for delivery of this work.

## Geoscience Surveys

### Major NATMAP project launched in Northwest Territories

The Western Churchill NATMAP project will focus on areas of high base metal, gold and uranium potential in the Rankin Inlet-Arviat-Baker Lake area west of Hudson's Bay. Its output will be the geoscience knowledge base needed to support mineral exploration in this area. Multidisciplinary in scope, the initiative involves government (GSC, Indian and Northern Affairs, and the Government of the Northwest Territories), exploration companies, and Canadian and U.S. universities. As a first step, the participating government geoscience agencies completed preliminary bedrock and surficial mapping, and minerals research in 1996. The intergovernmental working group, together with industry geologists, met in August 1996 for a field trip in the Rankin Inlet area. This advanced understanding of the geology and fostered government-industry cooperation.

### News from the Nechako Plateau NATMAP project

In its second year, the Nechako Plateau NATMAP project is producing results of particular interest to the mineral exploration industry. The multi-agency research team linked crustal extension with igneous activity and hydrothermal copper-gold ore systems; identified a volcanic sequence that is the same age and lithology as a gold-ore bearing unit in northern British Columbia; and dated, for the first time, the molybdenum mineralization of the Endako porphyry belt. At a workshop in September 1996, the Nechako team shared these exciting results with 20 mineral exploration industry geologists. A newsletter is available: telephone (604) 666-6413 or e-mail [bstruik@gsc.nrcan.gc.ca](mailto:bstruik@gsc.nrcan.gc.ca).

## Building on the Magdalen Basin NATMAP

The GSC, working with New Brunswick, Nova Scotia and university researchers, is completing a major study of the sedimentary rocks that form the southern and western perimeter of the Gulf of St. Lawrence. The petroleum industry is showing growing interest in this region, which may have potential for both oil and natural gas. Private sector efforts will benefit from newly available geological and geophysical maps at both 1:50,000 and 1:250,000 scale for this area, accompanied by new stratigraphic data and a new understanding of basin origin and evolution. Another recent milestone was the integration of data from a LITHOPROBE marine transect with the results of the geological mapping into an overall model which enhances the knowledge infrastructure for the basin. As it nears completion, plans are to broaden GSC efforts in the offshore Gulf of St. Lawrence, an area not formally addressed by the Magdalen Basin Project. This new work will be coordinated with other researchers, and industry participation will be pursued.

## Winnipeg focus of NATMAP geoscience program

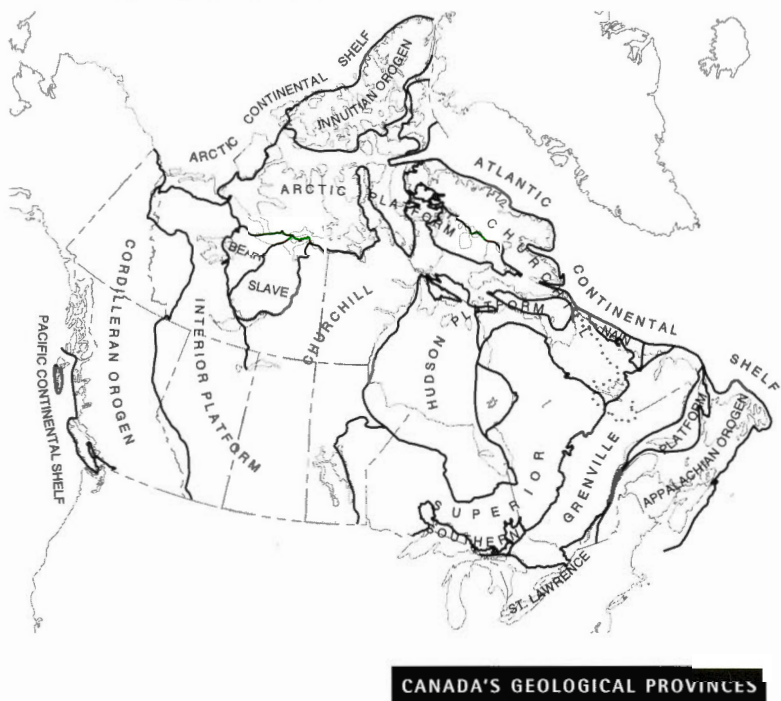
The GSC continues to play the key role in a multi-agency team addressing geoscience issues in the Winnipeg region. Surficial and bedrock mapping under the NATMAP program is now underway in a large area centred on Winnipeg, and the work has been expanded to include industrial mineral resources. Hydrogeological research will begin in 1998. Work by the GSC, with provincial agencies and universities, will examine regional groundwater processes, including cross-border topics, discharge of saline water from bedrock to the west of Winnipeg, freshwater recharge in surficial sediments from the east, and the freshwater recharge area of the Interlake region. This work will address regional and long-term issues of ensuring the quality and quantity of water supplies.

## NATMAP/LITHOPROBE: NATIONAL PARTNERSHIPS THAT WORK

**NATMAP is designed to increase the level and quality of geoscientific mapping of Canada. LITHOPROBE looks into the Earth to better understand its deep structure.**

*LITHOPROBE and NATMAP projects, with their teams of provincial, territorial, university and GSC researchers working with industry partners, have been an outstanding success in terms of scientific results, innovation, impact on Canadian industry, and the training and development of Canadian scientists.*

*These partnerships have played a fundamental role in the development of a truly integrated geoscience program at the GSC. They make essential contributions to the GSC's mandate to provide the national geoscience knowledge base, which forms the foundation for all private and public sector activities related to the sustainable development of mineral and energy resources, land-use decision making, and mitigating the impact of natural geological hazards.*





## Lake Winnipeg project

The second phase of this multidisciplinary project was completed in 1996. The project responded to public concern regarding shoreline erosion and water quality, and was co-funded by Manitoba Hydro, the Manitoba government and the GSC. Following a successful one-year project in 1994, the GSC began a gravity and uplift survey to measure the tilting of Lake Winnipeg, which may cause the lake to erode its southern shores. Funds were then raised for a second offshore survey, with Coast Guard support, and for a more intense study of shoreline processes. Links are established with several Canadian and U.S. universities, Fisheries and Oceans, and Environment Canada. Data collection from three wave-rider buoys is being managed by the University of Manitoba.

## NATMAP PROJECT ADVANCES LANDSLIDE AWARENESS AND ARCHEOLOGY

*Bedrock and surficial mapping in the Foothills region of southwestern Alberta identified the geological controls on landslides in the Livingstone Range. Extensive fresh cracks were discovered along the summit of Mount Livingstone. Failure along these cracks could result in a rock avalanche with a runout of many kilometres – the size of the famous Frank Slide. Mapping and cosmogenic dating of the Foothills Erratics train and other erratics showed that the Foothills have been glaciated by a continental ice sheet only once during the last glaciation. This lays to rest the hypothesis that humans first entered North America by way of an ice-free corridor between the Cordilleran and Laurentide glaciers at the maximum point of the last glaciation.*



Kazuharu Shimamura

FIELD WORK ON THE BLOOD RESERVE, ALBERTA.

## Towards a better understanding of the Grenville Geological Province

Integrated studies of geochronology, structural analysis and RADARSAT satellite imagery have been added to the cartographic surveys of the Portneuf-Mauricie and Mont-Laurier regions of Quebec. The result is new information about the nature and setting of the major plutonic suites in Grenville Geological Province. These studies, carried out concurrently with the Abitibi-Grenville LITHOPROBE project, have refined and extended the three-dimensional model of tectonic evolution for the southwest Grenville.

## Next and last phase of LITHOPROBE

LITHOPROBE is preparing for its fifth and final phase, proposed for 1998-2003. Of critical importance to this stage of the project is a global synthesis of results including the elucidation of pan-Canadian themes and research achievements that describe how the landmass was assembled. A LITHOPROBE subcommittee made up of GSC and university scientists is tasked with making major contributions to this synthesis. It met in December 1996 with earth scientists, funded by the Canadian Institute of Advanced Research, to investigate earth processes that could be studied using theoretical modelling approaches. LITHOPROBE's renowned seismic images of the underlying architecture of Canada are being used as the template for geodynamic models of continental lithosphere deformation at mountain belts.

## NATMAP partnership looks at Superior Geological Province

A major new geoscience partnership comprising the GSC, Ontario and Manitoba geological surveys, universities and industry was established this year. The program integrates the NATMAP bedrock geoscience initiative in western Ontario-northeastern Manitoba with the Western Superior LITHOPROBE transect, and with ongoing work by the provincial surveys, the GSC and the Canadian Mining Industry Research Organization (CAMIRO). The 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.

## LITHOPROBE surveys in Northern Ontario a success

The first of a number of major geophysical surveys to be conducted as part of LITHOPROBE's Western Superior Transect was carried out west of Thunder Bay. The GSC organized the refraction seismic survey, which involved participants from the Ontario Geological Survey, Atomic Energy of Canada, the universities of Durham (United Kingdom), Queen's, Saskatchewan, Toronto and Western Ontario, the U.S. Geological Survey and a U.S university consortium for seismology. The successful survey, which involved 550 seismographs deployed along each profile to record the seismic waves generated by 48,000 kg of explosives at 26 detonation sites, attracted much positive local attention. The seismic refraction survey will provide data on the nature and three-dimensional extent of the major rock types underlying the Western Superior Geological Province of the Canadian Shield.

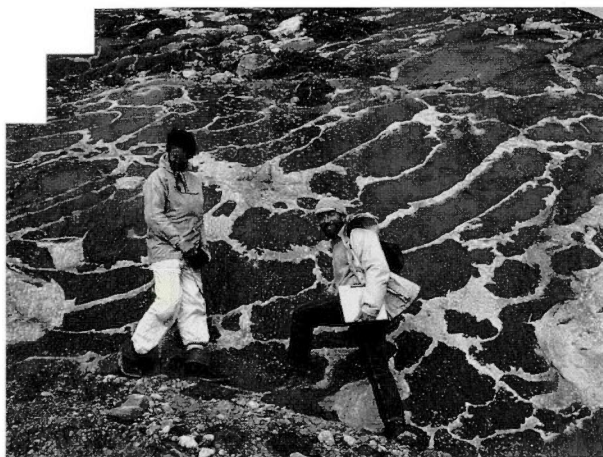
## Spinoffs from Slave Geological Province NATMAP project

Culminating several years of intense mapping activity, the Slave Geological Province surficial geology team published eight maps covering 70,000 km<sup>2</sup> of the Lac de Gras kimberlite field and the possible transportation corridor northward to Coppermine. Together with 11 reports on till geochemistry and kimberlitic mineral analysis, they serve the dual purpose of guiding mineral exploration and assisting in land-use management and planning. In collaboration with mining companies and Indian and Northern Affairs Canada, the GSC investigated the nature of massive ground ice and its possible impacts on development in the region. Laboratory work was completed on a detailed study of the glacial erosion of kimberlites and the mineralogy and geochemistry of glacial sediments eroded from them. Significant improvements to exploration methods for diamonds, as well as base and precious metals, should result from this research.

## Understanding the Lithosphere

LITHOPROBE geophysical surveys associated with the SNORCLE (Slave-NORthern Cordilleran Lithospheric Evolution) transect are providing an exceptional picture of the lithosphere. The SNORCLE transect stretches from the oldest rocks in the world, near Yellowknife, to some of the youngest at British Columbia's coast. An electromagnetic (EM) survey from Yellowknife to Nahanni Butte was conducted in August 1996 as the initial phase of LITHOPROBE's largest and most ambitious transect. The EM survey was followed by a seismic reflection survey in October. The seismic data shows the strongest reflections yet imaged from deep mantle structures (to 100 km). The geometry of these structures will help unravel the complex tectonic history of the oldest craton on Earth. The EM data provides an image of the thickness of the lithosphere; information that will guide the search for diamondiferous kimberlites.





Ron Ennsite

**TRACTOLITE PILLOWS CHILLED IN GRANITE MAGMA, NEWARK ISLAND, NAIN AREA, LABRADOR.**

## NEW GEOSCIENCE PROGRAM IN LABRADOR

*The Labrador Geoscience Knowledge Base Project, undertaken in partnership with the Geological Survey of Newfoundland and Labrador (GSNL), will map the bedrock geology north of the Voisey's Bay ore deposit and develop an integrated geoscience knowledge base for the Nain Plutonic Suite of north-central Labrador. In the 1996 field season, the GSC and GSNL collaborated on mapping and thematic geological studies in the area north of Nain, addressing key gaps in mapping at the north end of the Nain Plutonic Suite. The GIS-based geoscience information sets for the area, to be released on a CD-ROM next year, will include customized viewing and integration tools.*

## Pearya mapped

The complex geology of one of the most remote and rugged terrains in Canada – the Pearya domain in the northern Ellesmere and Axel Heiberg islands – has been the target of systematic GSC mapping and resource characterization research for almost 30 years. A full suite of eight regional maps, at 1:250,000 scale, was published in 1997, together with a definitive correlation chart of the stratigraphy of the region. Still in press is a major synthesis bulletin describing all aspects of the geology of this tectonically fascinating part of the Arctic.

## Collaboration contributes to \$7 million sales to China

A Chinese delegation visited the GSC to investigate the use of magnetotelluric (MT) methods and technology to explore for petroleum in a region of western China where seismic exploration methods perform poorly due to thick carbonate sequences. Phoenix Geophysics Ltd. (Toronto), which manufactures MT equipment, arranged the visit because of GSC participation in the joint Sino-U.S.A.-Canada MT survey in Tibet. Total sales of MT equipment to China by Phoenix Geophysics have been in excess of \$7 million, and are a direct consequence of the collaborative activities between the GSC and Phoenix in the development of MT instrumentation and methodologies.

## Technology transfer to Canadian geophysical contractors

The GSC has developed a data processing technique which automates the leveling of aeromagnetic data. Leveling is a process that merges data from surveys flown at different times and at different altitudes. Advances in GIS applications require accurate aeromagnetic leveling for data optimization. In the past, this has been a subjective, lengthy process whereas GSC's automated technique rapidly calculates a convergent solution that minimizes subjectivity and turn-around time. The GSC introduced this technology to Canadian geophysical contractors through on-site training sessions during quality control checks on national surveys being conducted for the GSC under contract.

## Fieldlog: a digital mapping technology success

The GSC is recognized by the geoscience community as a leader in the development of computer-aided technology to record geological data in the field and to facilitate the assembly of these data in “multi-layered” geological maps. This is due largely to Fieldlog, software initially developed by the Ontario Geological Survey and subsequently upgraded by GSC. The use of Fieldlog has greatly improved GSC’s capability to release maps to clients quickly following the field season. This feature has attracted external interest, with the result that many industry, academic and government groups have requested training from the GSC and have introduced Fieldlog into their mapping and exploration programs.

## Destination: North Magnetic Pole

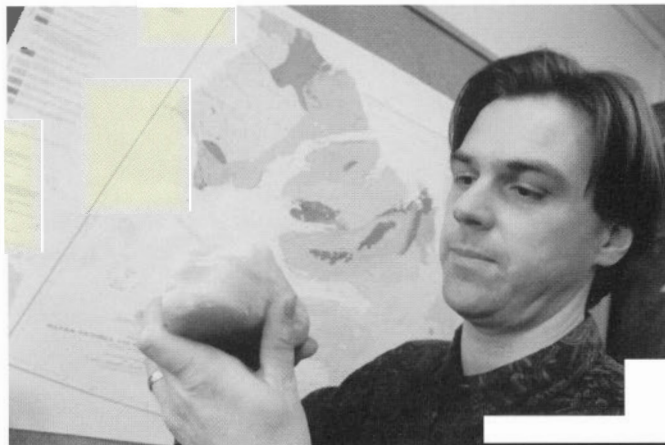
The GSC monitors the constantly changing location of the North Magnetic Pole, which in recent years has become a tourist attraction. Of the many expeditions setting out to visit it, few carry out proper procedures to locate the pole, which moves about 15 kilometres per year. In 1996, however, GSC responded to a request from the leader of a British expedition by loaning magnetometers and providing training in their use. The expedition successfully located the North Magnetic Pole and returned some useful information to the GSC. The GSC has agreed to support a similar tourist venture during 1997.

## ALABASTER FIND IN ARCTIC AIDS INUIT CARVERS

*Carvers in Holman on Victoria Island now have important new potential sources of carving stone close to their community. The discovery of massive gypsum beds (alabaster) in north-central Victoria Island in the summer of 1996 was an offshoot of fieldwork for a partnership project involving the GSC and Western Mining Company. The project stemmed from previous GSC mapping and minerals research on Victoria Island that revealed significant nickel-copper-platinum group element potential.*

*Alabaster is valued for its unique texture and white colour. Prior to the discovery, Holman and other Arctic communities had to import Brazilian alabaster at a cost of \$22 per kilogram. Local carvers and the Inuit Art Foundation heralded the find both for its artistic and economic importance.*


*The discovery, which attracted national media coverage, also built new bridges between GSC and Inuit carvers. Carvers now know that the GSC has the expertise to help them identify potential new sites for carving stone, and the GSC is more aware of the needs of the carvers and Inuit communities.*



The Ottawa Citizen

**GSC SCIENTIST ROBERT RAINBIRD EXAMINES ALABASTER HE DISCOVERED ON VICTORIA ISLAND.**





THROUGH MINERALS-RELATED STUDIES, the GSC ensures the availability of comprehensive knowledge concerning Canada's non-hydrocarbon mineral resources. This work includes assessments of domestic and foreign mineral potential and the development of new concepts and technologies for mineral exploration.

GSC's role is to provide the framework within which industry can discover the ore reserves required to sustain Canada's position as one of the world's leading suppliers of minerals and metals, to ensure that government has the geoscience information needed to formulate mineral policies in areas of federal jurisdiction, and to promote the technological capability of the Canadian exploration services industry.

## M i n e r a l s

### New Brunswick massive sulphide discovery

A multiparameter airborne geophysical survey conducted in New Brunswick's Bathurst mining camp contributed to the discovery by Noranda Exploration Ltd. of the Camel Back massive sulphide. The magnetic and conductivity responses of the deposit, combined with new geological, geochemical and structural evidence, suggest that there may be potential for other massive sulphide deposits in areas that have not been successfully explored using traditional methods and technologies. The survey was carried out as part of GSC's EXTECH II program, which is designed to develop, test and apply new concepts and methods for base metal exploration. The survey sparked a significant increase in claim staking and a renewed interest in the Bathurst area by several companies. A new series of 1:20,000 scale geological maps compiled using GIS techniques should further stimulate exploration interest in the region.

### Airborne surveys advance mineral exploration

Similar work, funded by British Columbia, helped to revitalize exploration at the Sullivan mining camp, with the publication of aeromagnetic/EM/radiometric data in both map and digital form. A very successful short course on how to interpret the geophysical data was given by GSC and British Columbia Geological Survey geoscientists for 30 prospectors and exploration geologists in Cranbrook the day before the data was released to the public. A local staking rush followed the data release. Aeromagnetic surveys over Victoria Island and Baffin Island, Northwest Territories, advanced reconnaissance diamond and base metal exploration. Sponsored by GSC and cost-shared with industry, these surveys led to increased staking activity.

## International connections for seafloor minerals studies

In addition to the work off Canada's West Coast with the Ocean Drilling Program, gold-rich massive sulphide deposits forming on active submarine volcanoes on volcanic arcs of the Western Pacific Ocean and the Mid-Atlantic Ocean Ridge are being studied in cooperation with German, U.S. and Australian researchers. These studies provide exciting insights into how these deposits form and the models derived are being used to assist in the exploration for ancient, terrestrial deposits.

## Major study of Kidd Creek deposit completed

GSC scientists, working with industry, universities and the Ontario government, completed a four-year, multidisciplinary study of the giant Kidd Creek base metal deposit near Timmins, Ontario. The results are being published by the Society of Economic Geologists (SEG)\*. Research on the Kidd Creek deposit indicated that the extensive package of high magnesium (komatiites) and high silica (rhyolites) volcanic rocks located in the deposit footwall may typify this exceptionally large deposit. This information will be used to guide future exploration programs in the region, and it has attracted several industry partners and continued support from the Ontario government. The work is an extension of the Kidd Creek study begun under the Northern Ontario Mineral Development Agreement.

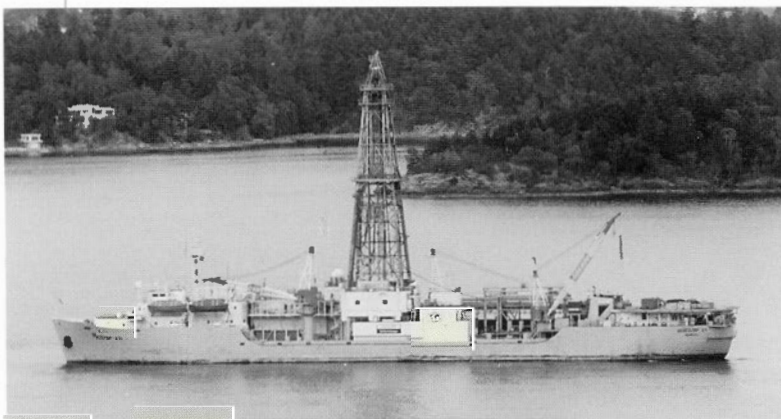
\* *Reference: The Giant Kidd Creek Volcanogenic Sulphide Deposit, Western Abitibi Subprovince, Canada, edited by M.D. Hannington and C.T. Barrie, SEG Monograph Number 10.*

## OCEAN DRILLING PROGRAM

### Seafloor massive sulphide discovery has implications for land deposits

*The international Ocean Drilling Program completed two drilling cruises off Canada's West Coast. These provided exciting new information on the processes of copper-zinc deposit formation. One cruise (Leg 170) established a long-term sub-seafloor experiment, using GSC-developed CORK technology (see page 22), that will show how heated water circulates and reacts within ocean-floor sediments, creating metal-rich fluids. This circulation-reaction process is a significant factor in the Earth's cooling history — one which partially controls the composition of the world's seawater.*

*The other cruise (Leg 169) continued to explore the largest copper-zinc deposit ever discovered on the seafloor, at Middle Valley about 200 km west of Victoria. The deposit, first drilled during Leg 139 in 1991, measures 104 metres thick by 200 metres wide. It is estimated to contain at least 15 to 20 million tonnes of massive sulphide, including zones which have greater than 20% zinc and 16% copper. The formation processes, morphology and alteration associated with this discovery have direct applications to exploration for terrestrial deposits.*



Sonja Bernhold

THE OCEAN DRILLING PROGRAM'S STATE-OF-THE-ART RESEARCH VESSEL, THE JOIDES RESOLUTION, IN SAANICH BAY, BRITISH COLUMBIA.



## Nickel-copper deposit exploration guides

New GSC studies, in partnership with Canamara Inc., identified several new anomalies in the Muskox Intrusion, Northwest Territories. New geophysical surveys and geological map compilations resulted in a major exploration initiative in the vicinity of this well-known layered, mafic intrusion. A new lithochemical database compiled for the Thompson Manitoba Nickel Belt, and revised ages on the Winnipegosis komatiite extended the known length of this mineralized belt, establishing new areas for exploration.



## Exploration in previously glaciated terrain

GSC research combining ice dynamics and Quaternary sediment composition was added to the Ashuanipi project of the *Ministère des ressources naturelles* in northern Quebec. One offshoot was the development of a new model for regional ice flow. Combined with the results of till geochemistry and the regional bedrock surveys carried out by provincial geologists, the model has led to the identification of zones with gold-bearing mineral potential. This integrated approach, which can be used to prepare guides for drift prospecting, was made available to the private sector.

## New exploration tools for massive sulphide research

The GSC, in cooperation with the Canadian Mining Industry Research Organization (CAMIRO), is in the second year of a four-year project on the use of regional alteration zones and sub-volcanic intrusions as exploration tools for volcanogenic massive sulphide deposits. The study is jointly funded by the GSC and 11 industry partners through CAMIRO. Areas under investigation include the Snow Lake area of Manitoba, the Clifford-Ben Nevis area of Ontario, Rouyn-Noranda, Quebec, and the Skellefte District of Sweden. The emplacement of subvolcanic intrusions (timing, location, extent) and their relation to convective, deposit-forming hydrothermal systems, is important in determining the potential for massive sulphide and other mineral deposits.

## Seismic methods applied to mineral exploration

As part of a collaborative project with industry, the GSC demonstrated the application of its first three-dimensional seismic studies to mineral exploration in the Sudbury and Mattagami mining camps, Ontario. In both camps, these studies demonstrated that deeply buried massive sulphide deposits can be directly detected using surface seismic surveys. This technological breakthrough increases the attainable exploration depth of surface geophysical techniques almost ten-fold, from 300 to 3,000 metres.

## Raising northern awareness of minerals

GSC scientists worked to inform local inhabitants about the mineral potential of Canada's north. They participated in public meetings at several northern communities with the goal of raising awareness of the importance of mineral development and how it can be achieved in a way that complements traditional pursuits. As part of this initiative, GSC scientists led a short course on mineral exploration at Grise Fiord. The students learned about basic earth science concepts (rock and mineral identification and information on claim staking), mineral policy issues, and current and future mining activities.

## Borehole test site an international success

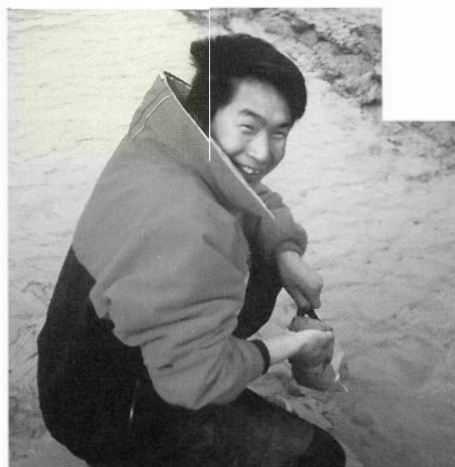
The McConnell Deposit Borehole Test Site in Sudbury is becoming internationally accepted as a standard for evaluating borehole geophysical instruments and methodology. The site, which GSC co-developed with INCO Ltd., the owners of the property, consists of 21 boreholes through and around the McConnell nickel-copper orebody. Their arrangement permits researchers from Canada and abroad to test instruments under a variety of ground conditions at various proximities to the orebody. It has been used to test borehole radar, radio and acoustic techniques, and is a valuable tool in developing three-dimensional deposit imaging.

## New imaging technology for mineral exploration

Thirty researchers and managers from three mining companies, five universities, Atomic Energy of Canada and the GSC, at a workshop in Ottawa, agreed to form a five-year consortium to develop and test computer hardware and software associated with downhole seismic imaging, with the ultimate goal of transferring this technology to industry. Preliminary GSC surveys had demonstrated this technique's practical application for mapping underground geological structures and delineating massive sulphide deposits at distances significantly greater than existing exploration techniques.

## MINERAL AND ENERGY RESOURCE ASSESSMENTS (MERA)

*The MERA program provides geoscientific information on mineral and energy resource potential to planners involved in the establishment of national parks on federal lands. GSC's approach to resource assessment involves upgrading the geoscience database of the area of interest to modern standards of mapping; integrating available geological, geochemical, and geophysical information; defining geological domains in the study area; applying conceptual models of mineral deposits and hydrocarbon reservoirs to the geological domains in the area of study; and estimating the likelihood of occurrence of the mineral and hydrocarbon deposit types in the area of study. A MERA project is underway for northern Bathurst Island in the Arctic Islands, with a report to be published in May 1998.*



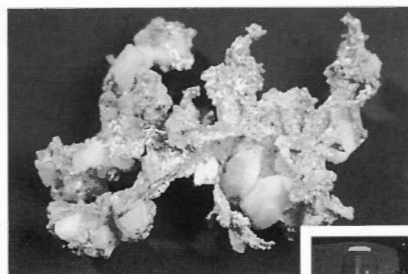
Lyn Anglin

**GSC FIELD ASSISTANT MATHEW MANIK FROM RESOLUTE BAY COLLECTING STREAM SEDIMENT SAMPLE FOR A GEOCHEMICAL SURVEY OF NORTHERN BATHURST ISLAND AS PART OF THE MERA PROGRAM.**

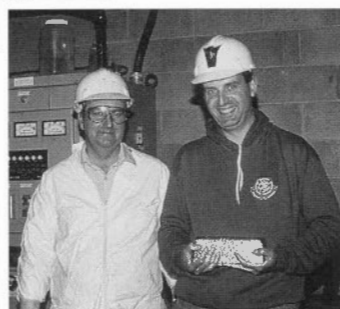


*Canadian industry leads the world in gold exploration. Gold occurs in many classes of deposits, and each requires specific exploration guidelines. The GSC develops improved models for gold deposit formation to assist exploration efforts. Some recent news:*

- The Hope Brook gold deposit in Newfoundland was definitively identified as being a “high-sulphidation” type and may be similar to gold deposits in the U.S. Carolina Slate Belt and South America. The geological parameters that have been defined can be used elsewhere in Canada as exploration guides for this type of high-grade, high-tonnage deposit. The research, along with the work done in the Avalon area in cooperation with the provincial government, is partly responsible for renewed exploration activity, with 1,800 new claims. Further exploration for similar deposits in the late-Precambrian Avalon Terrane of Atlantic Canada may be warranted.
- In the Abitibi region of the Superior Geological Province, studies of gold deposits associated with feldspar-rich, volcanic intrusive rocks showed that sedimentary rocks preserved along major fault zones provide favourable environments for the deposition of gold, and are thus new targets for exploration.
- Recent studies of gold occurrences associated with the late Cretaceous Tombstone Suite in Yukon’s Selwyn Basin confirmed that this region is highly prospective for diverse styles of gold mineralization. Of these, several occurrences of carbonate-hosted disseminated gold are the most “Carlin-like” in their characteristics. “Carlin-type” gold deposits are currently a major source of U.S. gold production in Nevada.
- Studies of world-class gold deposits in the Tapajòs region of Brazil, jointly funded by CIDA and the Geological Survey of Brazil, illustrated that widespread gold mineralization occurs in volcanic sequences not usually considered favourable for the concentration of gold. The study highlighted striking similarities between the geology of the Tapajòs region and that of parts of the Churchill Geological Province, Northwest Territories, where there may be a higher potential for gold than was previously recognized.

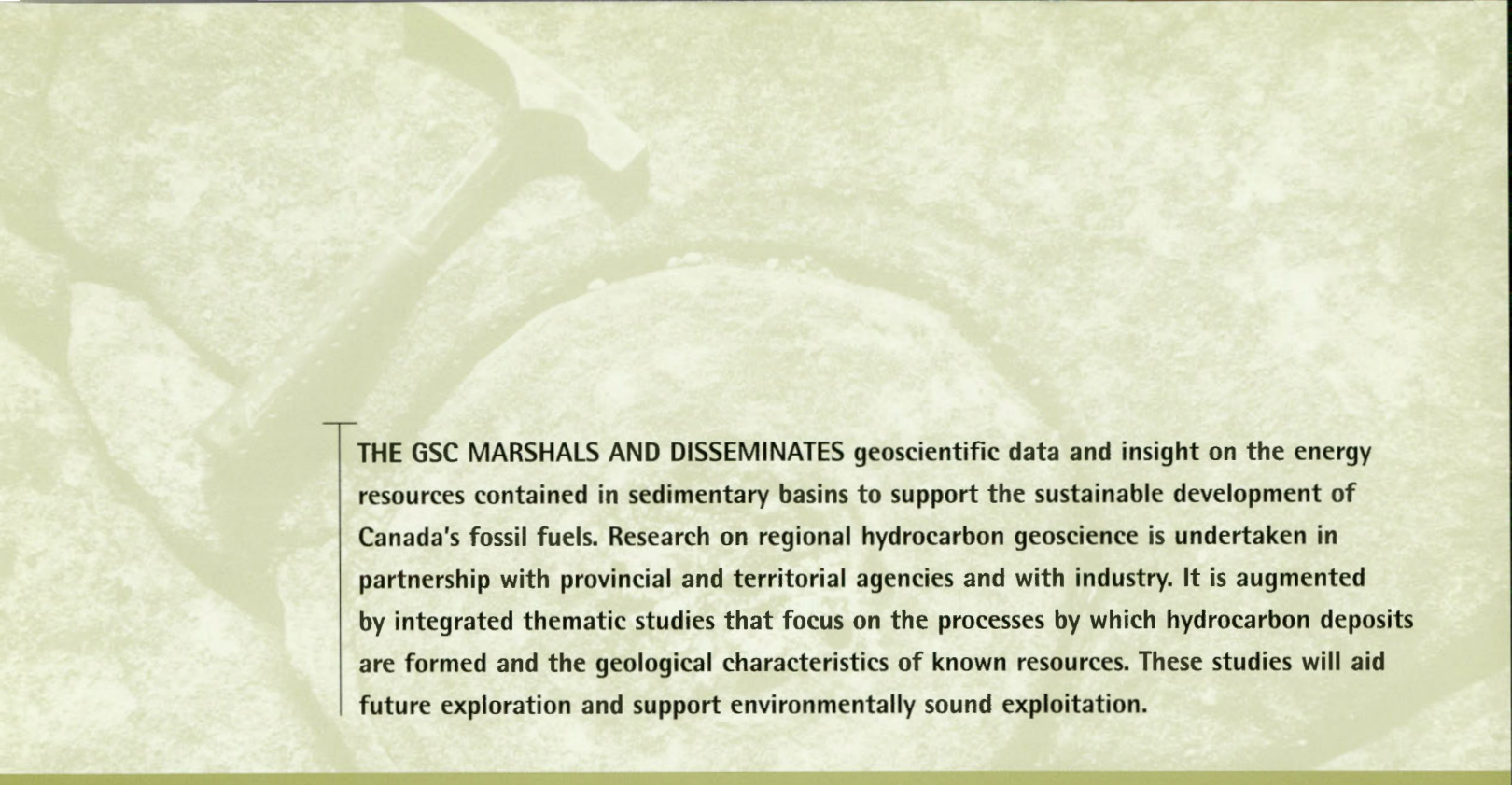


R. W. Boyle



Kathleen Lauzière

GSC GEOLOGIST BENOIT DUBÉ (RIGHT) AND BRUCE PITTMAN, ROYAL OAK MINES, WITH A HALF MILLION DOLLAR GOLD BRICK AT HOPE BROOK MINE, NEWFOUNDLAND. DR. DUBÉ'S RESEARCH HELPED TO ADVANCE UNDERSTANDING OF THE HOPE BROOK DEPOSIT AND TO DEMONSTRATE THAT THERE IS A DEFINITE POTENTIAL FOR HIGH SULPHIDATION EPITHERMAL STYLE GOLD DEPOSITS IN CANADA.



**THE GSC MARSHALS AND DISSEMINATES** geoscientific data and insight on the energy resources contained in sedimentary basins to support the sustainable development of Canada's fossil fuels. Research on regional hydrocarbon geoscience is undertaken in partnership with provincial and territorial agencies and with industry. It is augmented by integrated thematic studies that focus on the processes by which hydrocarbon deposits are formed and the geological characteristics of known resources. These studies will aid future exploration and support environmentally sound exploitation.

## Energy

### Significant oil discovery in Saskatchewan

Prolific oil production from Red River reservoirs highlights the hydrocarbon potential of lower Paleozoic strata in southeastern Saskatchewan. The initial discovery well (Berkley et al Midale 4-2-7-11W2) produced 31,016 cubic metres (195,091 barrels) of oil and only 218 cubic metres of water in its first ten months of production. This was followed by more than a dozen successful wells, making the discovery one of the most significant of this decade. The success, together with the reversion of non-producing deep oil and natural gas rights to the Crown beginning in April 1998, has stimulated renewed interest. In cooperation with some of the companies involved in the recent flurry of exploration, the GSC obtained samples of oils and potential hydrocarbon source rocks for organic geochemical and organic petrological analysis. This has allowed a reappraisal of the Upper Ordovician petroleum system in southeastern Saskatchewan.

### Hydrocarbon potential of the Appalachians

A GSC partnership with Shell Canada, in cooperation with INRS and *Université Laval*, has improved identification of the potential in reservoir rocks and source rocks in the Silurian-Devonian units of the Gaspé region. It has also provided a detailed geoscientific framework on which to base exploration work. A broader study is underway in the Humber belt and overlying Silurian-Devonian, in the eastern segment of the Canadian Appalachians, to assess their hydrocarbon potential.



## WESTERN NEWFOUNDLAND, A "NEW FRONTIER"

*The GSC played a pivotal role in stimulating the oil exploration boom in western Newfoundland. GSC studies redefined the structural and tectonic setting of the Appalachian front in western Newfoundland, creating exploration interest in the region by both junior and major companies. New industry drilling is planned as a result of four wildcat holes on and near the Port au Port Peninsula. GSC staff continue to present and publish new ideas and seismic interpretations about the area. Over 5,000 km of industry seismic reflection data, released into the public domain in March 1997 are now being assessed by the GSC for new research directions. These new data should provide key insights into the stratigraphy of the Anticosti foreland basin, and the detailed geometry of thin- and thick-skinned structures at the Appalachian front.*

Glen Stockmal



CAPE ST. GEORGE, WESTERN NEWFOUNDLAND,  
NEAR THE SITE OF RECENT OIL EXPLORATION.

## Better understanding of Devonian hydrocarbons

The Devonian Petroleum Systems Study is a multidisciplinary project to re-evaluate the potential, organic facies and maturity of Devonian source intervals, oil-oil and oil-source correlations, and hydrocarbon migration pathways within the Western Canada Sedimentary Basin. Initial results, as the project enters its third and final year, have modified understanding of Devonian petroleum systems within the basin and had an impact on exploration strategy. The 13 industrial partners gave the GSC access to proprietary data and samples for the study. The GSC is integrating the data with geology to develop models that will provide a better understanding of the occurrence of hydrocarbons in Devonian strata. Results are provided to partners in a timely fashion through annual reports, newsletters, formal oral presentations and informal discussions. All results will be made public over the next two to three years.

## Understanding oil migration

An international effort resulted in a new technique that uses trace molecules in crude oil to determine the migration distances from source rocks to the reservoir. With it, researchers can identify new economically viable oil accumulations near an existing producer. The technique was developed by a group of researchers from the GSC and collaborating oil companies and university laboratories in Europe, Asia and North America. At the request of several industrial partners, the GSC is setting up a new project to continue the migration study on several petroleum systems in the Western Canada Sedimentary Basin and elsewhere.

## Coalbed methane: an alternative fuel

A regional assessment of the methane in coal beds underlying the Alberta Plains was completed with funding from two major western Canadian pipeline companies. In addition to resource estimates and parameters related to economic production, the GSC produced an atlas of maps to optimize the location of future exploration. Preliminary in situ estimates are 6 trillion cubic metres (200 trillion cubic feet) of which 10% to 20% may prove recoverable. GSC's expertise in coalbed methane is internationally recognized. A GSC team, funded by the major Australian resource company BHP, examined and characterized coalbed methane potential in Australia.

## Oil and gas pipeline safety

A consortium, spearheaded by the GSC and including industrial and academic partners in Canada and Scandinavia, began a multi-year research program to study geomagnetically induced currents in oil and gas pipelines. These currents disrupt the operation of corrosion prevention systems, which minimize the effects of electrolytic corrosion in the pipelines. Excessive corrosion can result in leaks with potential for hazardous environmental consequences. Data-logging equipment was acquired and preparatory theoretical studies were undertaken during the first year of work.

## The power is out

The GSC completed a multi-year collaborative project with the electric power industry to study the detailed effects of variations in the geomagnetic field (such as magnetic storms) on several electric power transmission systems in Canada. Magnetic storms can result in serious damage and power outages by causing power transmission equipment to malfunction. Detailed analysis and modeling of the geomagnetically induced currents is leading to improved mitigation procedures by the power utilities.

## ECONOMIC POTENTIAL OF CANADIAN OIL AND GAS

*The GSC plays a leading national role in the characterization and identification of conventional Canadian oil and gas resources. GSC resource appraisals are the basis for a series of popular bulletins that describe these resources in detail. Of note over the past year:*

- *A new strategic alliance between the GSC and the Canadian Energy Research Institute, an economic "think-tank", led to a multi-client supply study of conventional gas resources in the Western Canada Sedimentary Basin.*
- *A comprehensive reassessment of the undiscovered conventional oil resource of the Western Canada Sedimentary Basin was completed. Results, which will be published shortly, will update the GSC best seller "Conventional Oil Resources of Western Canada" (1988).*
- *Working with the British Columbia government, the GSC completed assessments of the Pacific Marginal and Intermontane sedimentary basins. This was in response to a major provincial land-use plan.*
- *A reassessment of oil and gas potential in southwestern Ontario, presented to the Ontario Petroleum Institute, indicated that improved rates of oil and gas production would continue.*



Natural Resources Canada



## COAL RESOURCE MANAGEMENT TECHNOLOGIES

*Through its National Coal Inventory, the GSC has developed comprehensive geological models of much of Canada's coal resource base, along with resource management technologies that allow the determination of coal supplies and technological characteristics. These technologies provide tools to maximize the sustainable production of an important non-renewable energy resource, while minimizing the effects of mining and utilization on the environment.*

*In the face of declining coal supplies, the U.S. Geological Survey (USGS) has embarked on a five-year National Coal Resource Assessment program, funded at US\$18 million per year, to be completed in 1999. USGS recognizes the power of the geological modeling and resource management technologies developed by the GSC to optimize the American program, and discussions are now under way to apply them. GSC's resource management technologies, coal resource reporting systems and the development of an international coal trace element database are part of a Memorandum of Understanding between the GSC and USGS.*

## Meteorite impact structures

Steen River, in northern Alberta, is a hydrocarbon play which is coincident with a meteorite impact structure. The GSC is applying its unique knowledge of craters, in combination with geophysical data, to help industry refine its geological model of the area. A Canadian company is taking advantage of that same expertise to focus its mineral exploration program at the Chicxulub crater in Mexico.

## Airborne surveys and the search for hydrocarbons

Increased aircraft positioning accuracy, combined with GSC-developed data acquisition standards and data processing advances, has rekindled interest in the application of aeromagnetic data to the search for hydrocarbons. GSC-industry aeromagnetic surveys contributed to hydrocarbon exploration activities over the Liard Plateau and in southern Saskatchewan by providing information on basement topography and fault control.



J.D. Hughes

**THREE-DIMENSIONAL IMAGE OF SUBSURFACE  
GEOLOGY OF THE HIGHVALE COALFIELD,  
ALBERTA.**

## East Coast Oil and Gas

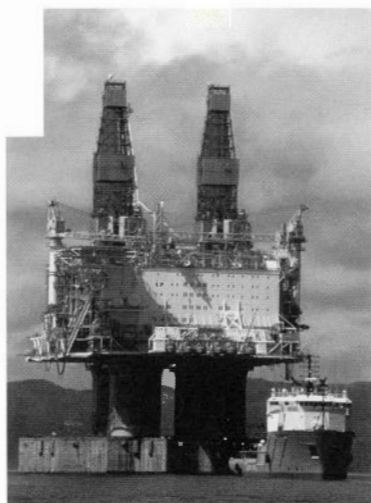
*There is gathering momentum in oil and gas industry exploration and production in East Coast frontier basins, and the GSC is playing an important consultative role in these developments. Recent actions by several companies confirm the increasing importance that East Coast energy opportunities have for their strategic business plans. Significant activity is taking place:*

- On the Grand Banks of Newfoundland, the Hibernia production platform is on site and oil production is expected to begin in late 1997. Several exploration wells are also scheduled during the next two years, and oil production from the Terra Nova and Whiterose fields is a possibility before the turn of the century.
- On the Scotian Shelf, the Sable Offshore Energy Project's strategy targets the development by 1999 of six gas fields containing an estimated three trillion cubic feet of natural gas, estimated worth \$2 billion.
- On Newfoundland's west coast, promising test results released in August from a well drilled on the Port au Port Peninsula in 1995 have stimulated further interest in the region, and several companies, including juniors, are exploring other areas of western Newfoundland.
- On Georges Bank, a federal/provincial panel is assessing the environmental and socio-economic impacts of allowing oil and gas exploration to proceed after the current moratorium expires on January 1, 2000.

There is every indication that the renewed interest of the companies is long term. For example, during the past year, several petroleum industry teams requested briefings from the GSC, both in Dartmouth and Calgary, on its "corporate memory" of East Coast basin petroleum geology and on the completeness and availability of GSC's extensive offshore databases.

The GSC is concentrating on site-specific, client-focused studies such as hydrocarbon charge modeling of the Hibernia drainage area as an aid to production. It is also involved with environmental issues concerning offshore production hazards related to the Hibernia development site and future production sites such as Terra Nova and Venture gas.

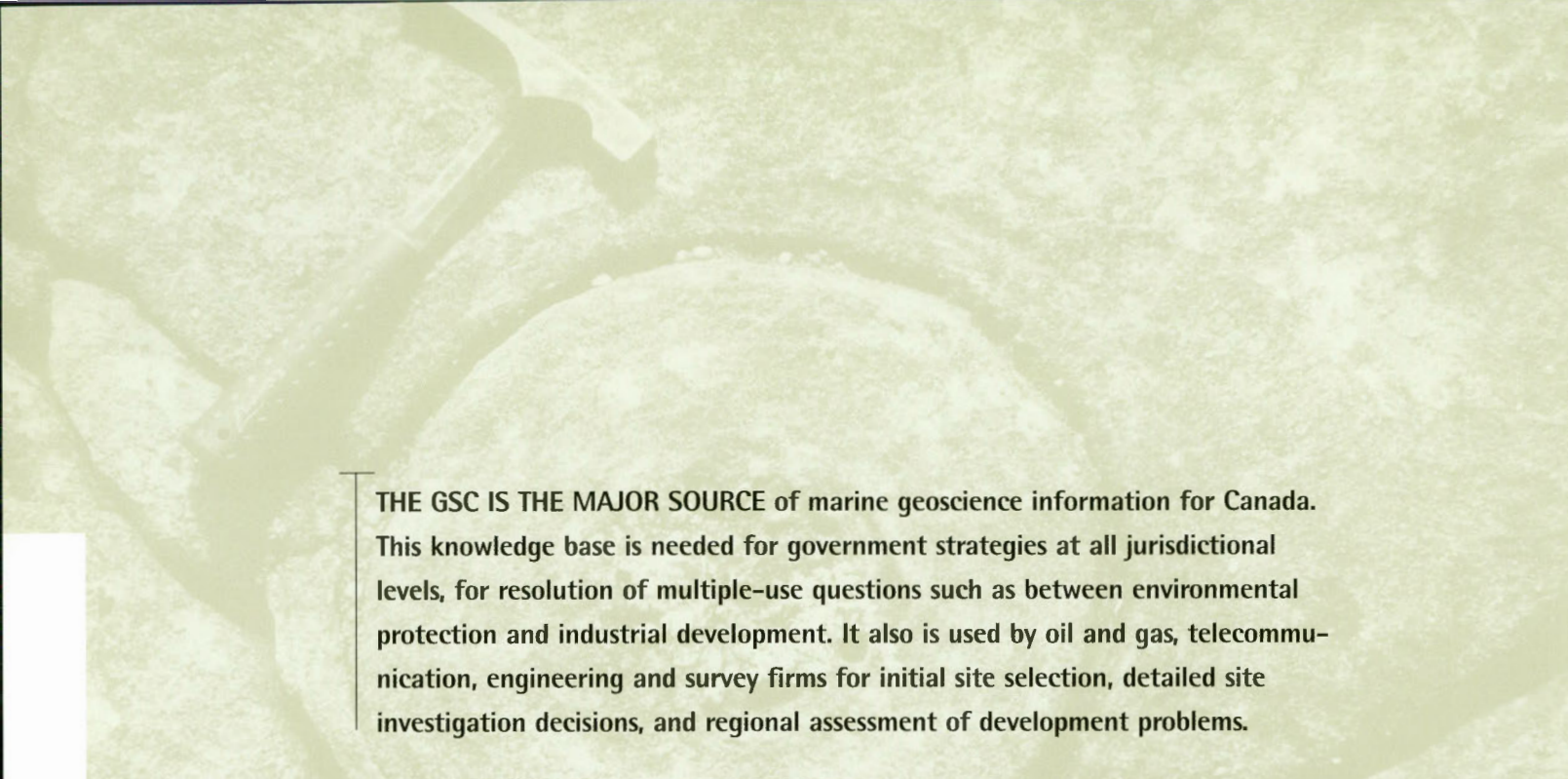
The resurgence in offshore oil and gas development and exploration in the eastern Canadian offshore has also led to a need for regional and site-specific seafloor studies. The GSC is working with industry and regulatory partners to decrease risks to seafloor structures by enhancing understanding of sediment transport, seafloor damage from keel-dragging icebergs, and sediment failure conditions.



Hibernia Management and Development Company Ltd.

**TOW-OUT OF HIBERNIA PLATFORM TO THE GRAND BANKS IN MAY 1997. THE PLATFORM STANDS 224 M HIGH AND WEIGHS NEARLY 600,000 TONNES.**





**THE GSC IS THE MAJOR SOURCE** of marine geoscience information for Canada. This knowledge base is needed for government strategies at all jurisdictional levels, for resolution of multiple-use questions such as between environmental protection and industrial development. It also is used by oil and gas, telecommunication, engineering and survey firms for initial site selection, detailed site investigation decisions, and regional assessment of development problems.

## Marine Geoscience

### Earthquake “footprints” on the ocean floor

A scientific cruise, using geophysical surveying methods, found evidence of recent faulting (deformed and displaced sediments) on the seafloor of the Strait of Juan de Fuca off the West Coast. These might be linked to earthquake activity. On land such features are difficult to identify because they are easily obscured by erosion or masked by vegetation. They show up clearly on the seafloor using geophysical surveying methods such as seismic reflection and sidescan sonar. The second phase of the project, to be conducted this year, will involve detailed study of the areas with disturbed sediments. This work is carried out cooperatively by the GSC and the U.S. Geological Survey with funding from the U.S. National Earthquake Hazard Reduction Program.

### Fortress of Louisbourg: preserving the past

Collaborative work by the GSC, the Canadian Hydrographic Service and Parks Canada resulted in new information that will help future interpretation and restoration efforts at Cape Breton’s popular tourist site, the Fortress of Louisbourg. In October 1996, researchers mapped the seabed around the fortress, using the new Simrad EM-3000 digital multibeam survey technology which provides multi-beam bathymetry. This provided, for the first time, a very detailed view of the seabed around the fortress. By combining the digital seabed images with digital aerial photographs of the surrounding terrain, a complete and seamless picture of the land-sea environment was provided without the obstruction of water cover. Local fishermen and residents were astounded at the detail they could see on the bottom of their harbour. The information will be used by geologists, archeologists and engineers for a variety of purposes.

## Aerial video of the Bras d'Or Lakes, Nova Scotia

The GSC and the Canadian Coast Guard completed a detailed aerial video survey, in June 1996, along about 885 km of the shoreline of the Bras d'Or Lakes in Cape Breton. The GSC uses the video footage primarily for mapping the geology of the area and the sensitivity of shoreline to possible effects linked to global change, while the Coast Guard uses it for emergency oil spill response activities. The footage, however, has many other applications for external clients, ranging from land use to tourism. Of particular interest for this mission, at the request of local Aboriginal groups, the videos cover several native communities in the area, as well as primary oyster, trout and salmon cage sites, potential herring spawning grounds and areas of known lobster fishing in the lakes. The Bras d'Or tapes add to a collection of aerial coastal videos that the GSC makes available to the public. Video coverage includes Nova Scotia, New Brunswick, Prince Edward Island, most of Newfoundland and parts of the Arctic coastline.\*

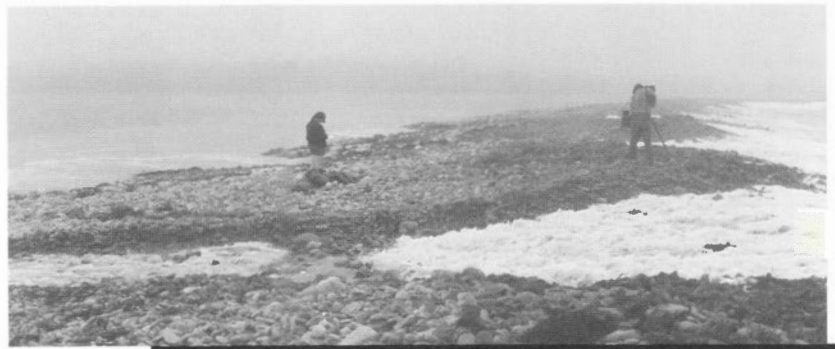
### GSC survey supports Irving Whale recovery

In support of the *Irving Whale* Recovery Project, the GSC and Canadian Coast Guard completed a detailed aerial video survey along the shores of Iles de la Madeleine in June 1996. In addition, a detailed survey was completed of Plage and Dune de l'Ouest in support of activities to recover bags of oil that were disposed in the backshore in 1970 after the original *Irving Whale* spill. The video will be used for documenting the physical character of the shoreline, changes in its morphology and land-use activities. It, too, is available for general distribution.\*

\* For more information about these video products, please contact Bob Taylor or Dave Frobel at (902) 426-7736; fax: (902) 426-4104.

## HURRICANE HORTENSE STRIKES ATLANTIC CANADA

*GSC scientists examined the impact of Hurricane Hortense on the coast and beaches of Nova Scotia. Hortense hit Nova Scotia on September 15, 1996, causing damage to several coastal communities. Strong winds, combined with high tides, produced a positive surge of 1 metre at Halifax. A maximum significant wave height of almost 9 metres was recorded. Physical impacts of Hortense were measured at several sites near Halifax. Gravel and sandy barrier beaches enclosing lagoons were most severely affected. The barriers were overtopped and lagoons, backshore vegetation and adjacent lowlands were flooded. Some low barrier beaches were pushed landward 10 to 20 metres during the hurricane. Higher beaches backed by dunes or gravel ridges were less severely affected by minor scouring of the seaward duneline. Sequential surveys of the same shore sites, illustrated their post-storm recovery and the resilience of different shore types to major storm events.*



Robert Taylor

View of Story Head beach, Nova Scotia, one of GSC's coastal monitoring sites, the morning after Hurricane Hortense. Waves completely overwashed the beach, flattening it and moving it 13 to 22 metres landward. Continued monitoring showed that the beach rebuilt its crest to near pre-storm elevations within four months.



## Coastal sediments and the human factor

To understand the processes that transfer waste materials from land to sea, the GSC carried out studies in marine environments associated with major urban centres: Halifax Harbour and the Fraser Delta (Vancouver). Identical methods were used to collect sediment cores and to measure sedimentation rates and metal concentrations. Natural and anthropogenic (human) sources and sinks, regional geometry, water budgets and tides are different in each area. Halifax Harbour has poor water circulation, allowing high levels of zinc, copper, lead and cadmium to accumulate. For Vancouver, these are substantially lower because effluent processing is better and because the large volume of natural sediment supplied by the Fraser River dilutes the anthropogenic materials to such a degree that they are below the detection limit. These two projects are providing information that will be used by local agencies to monitor and manage effluent discharge.

### Marine Data and Samples Repository

The GSC is the principal repository for marine acoustics, magnetic and gravity survey data; sediment grab and core samples; and rock and paleontological collections resulting from government, industry, university collaboration in Canada's offshore areas. The collection includes:

- 1.3 million line km of seismic reflection and refraction profiles
- 8,000 km of deep seismic reflection data
- 1.7 million offshore shipborne magnetic observations
- 9,000 core stations from more than 500 cruises
- 22,000 m of sediment cores
- 200,000 seafloor sediment and rock samples
- 800 borehole records
- a biostratigraphic, geographic, and taxonomic database with more than 825,000 records
- BASIN, a digital database of geological and engineering information for about 300 offshore petroleum industry and exploration wells. The database can be previewed at our Website.

For information on how to access this information, contact Iris Hardy, telephone: (902) 426-6127; fax: (902) 426-4465, or visit our Website: [agcwww.bio.ns.ca](http://agcwww.bio.ns.ca)

## Marine instrument development

The right tools are often not available for geoscientific research, so the GSC has had to develop them in-house. Many of GSC's innovations in instrument development have been adopted internationally as industry standards or have gone on to be commercial successes. A few recent examples are:

### ➤ CORK

These devices seal deep seafloor boreholes and allow geophysical observations to be made long after drilling has taken place and drilling disturbances have dissipated. Data are collected over periods of years, and recovered periodically with a manned or robotic submersible vehicle. CORKs have been used primarily for hydrologic experiments, including long-term monitoring of formation temperatures and pressure, fluid injection testing, and continuous sampling of formation fluids, although the CORK system can be tailored to other experiments easily. To improve overall cost efficiency and achieve even greater flexibility, a new CORK system is being designed that will be deployed with a normal oceanographic ship. This will reduce the time required of the drilling vessel, and allow previously drilled holes to be accessed more easily. For more information, contact Earl Davis at (250) 363-6453.

### ➤ MARINE ELECTROMAGNETIC SYSTEM

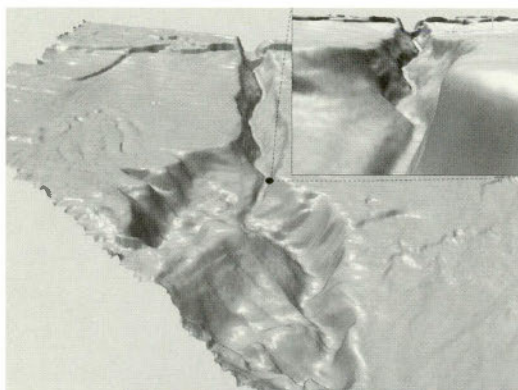
Comprising a transmitter and a string of three receivers which are towed along the seafloor, this unique system measures the electrical conductivity of the seafloor to a depth of about 20 meters. Measurements can be converted to apparent porosity, which, with bottom sampling, can be interpreted in terms of the composition of the seafloor. This determines how the seafloor sediments will respond to a given load and how easy the sediment will be to dredge. These physical properties are important when considering seabed stability and are basic parameters to any infrastructure design in the coastal zone. The system proved its worth this year in a survey carried out with Woods Hole Oceanographic Institution off the coast of California. Several marine geoscience companies are also interested in it for international harbour surveys. For more information contact Ralph Currie at (250) 363-6419.



## VISUALIZATION TECHNOLOGIES AT THE GSC

*The GSC is a world leader in the development and application of marine geoscience digital data technologies. This capability allows the acquisition, processing, analysis, interpretation and display of vast quantities of marine geophysical and geological data from the seabed, the shallow sub-surface and the deep sub-surface. Unique contributions include the development and use of visualization technologies that revolutionize the way marine geoscientists view their increasingly complex data sets and, most importantly, the key inter-relationships between different attributes of the data.*

*Multibeam data collection and processing technologies have made dramatic gains in mapping resolution and coverage of coastal and offshore areas, with a benefit for the fisheries and offshore engineering sectors for sea-bottom habitat and stability studies. In the shallow sub-surface, these technologies allow an increased understanding of geotechnical engineering issues associated with offshore development projects such as Hibernia. In the deep sub-surface, high resolution, 3-D examination of structural and depositional associations are now possible, ultimately aiding geoscience risk assessment for petroleum exploration and production.*



**SHADED RELIEF OF HIBERNIA PALEOCENE CANYON WITH INSERT LOOKING UP THE CANYON. BOTH WERE CREATED WITH 3-D SEISMIC INTERPRETATION AND VISUALIZATION SOFTWARE OF LANDMARK GRAPHIC CANADA.**

## Geophysical Data and Services

### Aeromagnetic and Gravity Data

GSC's Geophysical Data Centre provides aeromagnetic and gravity data for geoscience research by industry, government and academia. Customized digital data, colour plots and line contours available on most media types or via FTP:

Geophysical Data Centre  
Geological Survey of Canada  
1 Observatory Crescent  
Ottawa, Ontario K1A 0Y3  
Telephone: (613) 995-5326  
Fax: (613) 952-8987  
E-mail: [infogdc@agg.nrcan.gc.ca](mailto:infogdc@agg.nrcan.gc.ca)  
Website: [gdcinfo.agg.nrcan.gc.ca/gdinfo/](http://gdcinfo.agg.nrcan.gc.ca/gdinfo/)

### Airborne gamma ray/magnetic/VLF-EM data

The GSC collects and publishes combined gamma ray spectrometric, aeromagnetic and VLF-EM data as maps and/or digital data accompanied by SurView, a viewing and printing application. It also maintains calibration facilities for airborne and field portable gamma ray spectrometers; supervises airborne survey contracts; and gives training and workshops.

Airborne Geophysics Section  
Geological Survey of Canada  
594-601 Booth Street  
Ottawa, Ontario K1A 0E8  
Telephone: (613) 992-1235  
Fax: (613) 996-3726  
E-mail: [kford@gsc.nrcan.gc.ca](mailto:kford@gsc.nrcan.gc.ca)  
[www.geophys.gsc.nrcan.gc.ca/\\_airgs/hp\\_e.htm](http://www.geophys.gsc.nrcan.gc.ca/_airgs/hp_e.htm)

### Geomagnetic Data

The GSC has a substantial archive of analogue and digital geomagnetic data, collected over many years. Digital data from the Canadian Magnetic Observatory Network, which spans the length and breadth of the country, are telemetered to the Geomagnetic Laboratory near Ottawa. Recent data are viewable via the Geomagnetism Website at [www.geolab.nrcan.gc.ca/geomag](http://www.geolab.nrcan.gc.ca/geomag)

G. Jansen van Beek  
Geological Survey of Canada  
Geomagnetic Laboratory  
1 Observatory Crescent  
Ottawa, Ontario K1A 0Y3  
Telephone: (613) 837-1067  
Fax: (613) 824-9803  
E-mail: [vanbeek@geolab.nrcan.gc.ca](mailto:vanbeek@geolab.nrcan.gc.ca)



## Groundwater

*Groundwater is a strategic, natural resource that is more abundant and cleaner than surface-water resources in lakes and rivers. It is also a crucial, but unseen, factor in the health of Canada's rivers and wetlands, and it is the source of water supply for more than 25% of Canadians. Groundwater resources in Canada have not, however, been mapped in a manner that would permit determination of the extent, potential importance, and vulnerability of the resource.*

The GSC, working with provincial partners, has developed a successful new exploration model for identifying major untapped groundwater reservoirs in the Oak Ridges Moraine in southern Ontario. This groundwater initiative focuses on resource mapping as viewed using a three-dimensional geological model. This exploration plan should allow municipalities to find high-yield, municipal-supply-scale groundwater resources in thick (~200 m) drift-covered areas.

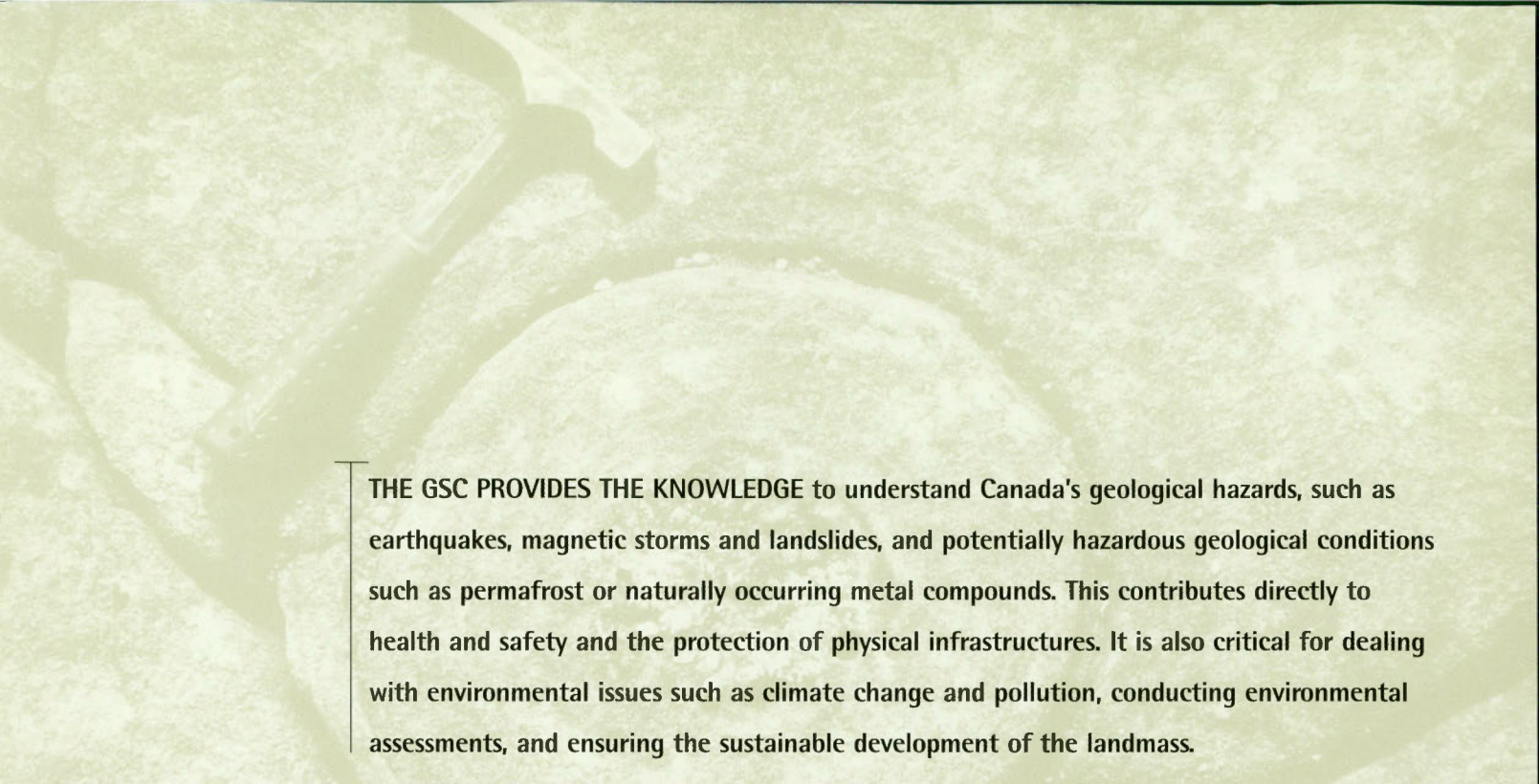
Municipal engineers are increasingly turning to lower quality, higher-priced, piped surface water as an alternative to groundwater because a strategy for finding groundwater has not been developed for glacial terrains. The proposed groundwater search model has been successful

in identifying potential municipal supply in three wells drilled using the model. The technology used to develop the groundwater strategy (e.g., reflection seismic surveys, detailed sediment mapping) is being transferred to the municipal and private sector through papers, field trips, workshops and joint working ventures.

The work in the Oak Ridges Moraine serves as a pilot for similar work in other thick-drift areas of the country, particularly in the populated regions of southern Canada. Efforts to ensure the security of Canada's drinking water supplies, and to confirm water supplies required for economic development, are intensifying across Canada.



THE OAK RIDGES MORaine IS A MAJOR GROUNDWATER SOURCE FOR OVER THREE MILLION RESIDENTS AND INDUSTRY IN THE GREATER TORONTO AREA. THE MORaine NourISHES 30 WATERSHEDS AND SUSTAINS A VIBRANT COLD-WATER FISHERY, ECOLOGICALLY SENSITIVE WETLANDS AND KETTLE LAKES. THE AREA IS ALSO THE SITE OF SEVERAL OVER-CAPACITY LANDFILLS.



**THE GSC PROVIDES THE KNOWLEDGE** to understand Canada's geological hazards, such as earthquakes, magnetic storms and landslides, and potentially hazardous geological conditions such as permafrost or naturally occurring metal compounds. This contributes directly to health and safety and the protection of physical infrastructures. It is also critical for dealing with environmental issues such as climate change and pollution, conducting environmental assessments, and ensuring the sustainable development of the landmass.

## Environment

### **New GSC program: Metals in the Environment**

Growing concern over the effects of metals in the environment and the potential for national and international regulations concerning the use of metals, makes it essential that Canadian policies and regulations are founded on a sound geoscientific understanding. GSC's new Metals in the Environment (MITE) initiative responds to this need. MITE is a five-year program of research into the natural sources of metals in the environment, their rates of release from geological materials, their fate once released, and ways of differentiating metals released by human activity from those of natural origin. A major objective will be to better understand the processes that control the mobility and immobility of metals in soils and sediments. Cooperative

research will be carried out with several partners including Environment Canada (sources of mercury in the environment) and Fisheries and Oceans (high levels of mercury and arsenic in fish in northern Canada).

### **Landslides database and management tools**

By integrating information from university, government and private sources, the GSC is producing a georeferenced database of landslides that have affected the St. Lawrence and Saguenay lowlands of Quebec over the last three centuries. The database meets the needs of potential users of the geoscientific information, particularly those involved in land management.





Steve Evans

**FRASER CANYON TRAIN DERAILMENT**

In March 1997, GSC scientists helped the Transportation Safety Board of Canada establish the cause of a major train derailment in the Fraser Canyon on CN's main line. A landslide (or landslides) created a depression into which an eastbound CN train plunged, resulting in the death of two crew members. Two locomotives and nine railway cars carrying goods from the Pacific Rim were also destroyed. The landslide partially undermined the Trans-Canada Highway, visible at the top of the photograph, causing a temporary closure of one lane. The derailment followed a rapid period of snow melt. The Fraser Canyon derailment illustrates the vulnerability of Canada's transportation infrastructure to landslide hazards.

**Groundwater project in Quebec**

Substantial progress was made in the first year of the regional hydrogeology project in the Portneuf region of Quebec. This pilot project to map aquifers is the result of collaboration with INRS-Géoresources, the provincial *Ministère de l'Environnement et de la Faune*, Université Laval, municipal authorities and the private sector. The goal is to develop a methodology that will be used by the municipal authorities in Quebec when implementing the new provincial policy on groundwater management. An important first step was consultation with partners and potential users to determine the most appropriate format of the resulting maps.

**Earthquake shaking of buildings**

On May 3, 1996, a magnitude 5.1 earthquake occurred near Duvall, Washington, about 180 km south of Vancouver. The earthquake, which was felt throughout B.C.'s lower mainland and southern Vancouver Island, triggered nine lunch-box-sized digital strong motion instruments in networks deployed by the GSC and B.C. Hydro. All data was analyzed by GSC scientists under an arrangement with B.C. Hydro. Of particular note, data from five instruments located on the deep soils of the Fraser River delta, south of Vancouver, provided a big step forward in our understanding of the response of the heavily developed Fraser Delta to earthquake shaking.

The energy from an earthquake affects buildings of different heights, over different depths of soils, differently. At all instrument sites in the Fraser delta, the shaking measured is less in the frequency range that damages one or two storey buildings – the most common type of structure in the delta. As expected, and as included in the National Building Code, shaking is greater in the frequency ranges that damage taller structures; however, it significantly exceeds the provisions in the National Building Code at some sites near the edges of the delta.

## Economic impact of the earthquake hazard program

By understanding the distribution and dynamics of earthquakes, building standards can be tailored appropriately, minimizing damage and loss. The economic benefit of GSC's National Earthquake Hazards Program (NEHP), through its influence on the National Building Code, was recently assessed. The estimated reduction in the losses that would be incurred from large and small earthquakes that occur in the seismically active areas of Canada, after considering the cost of compliance with the code, is more than \$100M per year – or a 40-fold return on our investment in earthquake hazard research under the NEHP. All Canadians share in the benefits through adjusted insurance costs, and reduction in the federal tax costs for disaster relief. The more we know about earthquakes in Canada, the better we can be prepared to withstand their effect.

## Why do we study earthquakes?

Exports are crucial to the Canadian economy and virtually all of Canada's exports pass through the west coast or the St. Lawrence River Valley – Canada's two most earthquake prone areas. The 1995 Kobe earthquake ( $M=6.9$ ) essentially destroyed the port of Kobe. A major earthquake in either the St. Lawrence River Valley or the west coast would have a significant impact not only on the local population, but on the national economy. By studying the location and mechanisms of earthquakes the GSC ensures, by its input into the National Building Code, that Canada is as well prepared as possible in the event of a large and damaging earthquake.

## Tree rings illuminate past environments

A GSC research partnership with INRS, the City of Montreal and the *Institut de recherche en biologie végétale* applied dendrogeochemical analysis to the environmental evaluation of certain green spaces in the City of Montreal. This approach, based on the principle that the geochemical composition of each growth ring in a tree reflects that of the soil when it was formed, allows a reconstruction of past environmental conditions. The study highlighted the importance of soil characteristics in the mobility and bioavailability of contaminants. The results provide a solid basis for environmentally responsible development of these sites.



Harvey Thorpe/Johnson

### RED RIVER FLOODING TRIGGERS NEED FOR MORE STUDY

As a result of the disastrous flooding of the Red River in spring 1997, the GSC began surficial geology mapping and stratigraphic studies to examine the long-term history of flood size and frequency, as well as the relationship between the geomorphic evolution of the river and flood frequency. This work should influence efforts to enhance flood preparedness and public safety.



## Global Change program

GSC's ongoing global change program contributes to improving climate models and to our understanding of climate system processes and dynamics, and greenhouse gas cycles. It also addresses potential preliminary impacts of global climate warming. Project results were released at several key workshops, including: the GSC contribution to the multi-agency Mackenzie Basin impact study; global change impacts in the Palliser Triangle; and a regional synthesis of our current knowledge of climate change and potential impacts on Atlantic Canada. Data from all this research will contribute to the *Canada Country Study*, a national look at the potential impacts of climate change.

A major conclusion of the report *Science of Climate Change*, released by the International Panel on Climate Change, was that researchers around the world now agree that there is a discernable human influence on today's climate. The GSC is reviewing its program in light of this global consensus.

## SUN SPOTS AND MAGNETIC STORMS

*After several years of relative quiet in its 11-year cycle of activity, the sun is beginning to show its spots once again. As a result, over the next several years, Earth will experience more frequent and more intense magnetic storms that can play havoc with such essential technologies as electric power systems and communications satellites.*

*As part of a worldwide network, the GSC operates a **Magnetic Activity Forecasting Centre** that produces warnings of magnetic storms. A new automatic forecasting process is available.*

Contact: Richard Coles

Telephone: (613) 837-4561

E-mail: [coles@geolab.nrcan.gc.ca](mailto:coles@geolab.nrcan.gc.ca)

Website: [www.geolab.nrcan.gc.ca/geomag/e\\_forcas.html](http://www.geolab.nrcan.gc.ca/geomag/e_forcas.html)

*The GSC **Geomagnetism Website** provides a greatly expanded service to clients. It provides access to data, magnetic declination information, information on the North Magnetic Pole, magnetic storm forecasts, and other geomagnetism activities.*

Contact: Jennifer Parmelee

Telephone: (613) 837-4241

E-mail: [parmelee@geolab.nrcan.gc.ca](mailto:parmelee@geolab.nrcan.gc.ca)

Website: [www.geolab.nrcan.gc.ca/geomag](http://www.geolab.nrcan.gc.ca/geomag)

## Seafloor cores record Earth's history

The Ocean Drilling Program work, August 19 to 21, 1996, in Saanich Inlet, British Columbia, exceeded all expectations. High quality sediment cores (as deep as 120 m below the seafloor) were successfully collected from the deepest part of Saanich Inlet. Initial analysis indicates that the cores contain a complete record of seasonal climatic and oceanographic change during the Holocene (past 10,000 to 12,000 years). This information will be crucial to establishing the "ground truth" for climate models and documenting the nature of local environmental conditions during periods of rapid change which have occurred in the past. This, in turn, will provide insight into anticipated terrestrial vegetation and oceanographic conditions in the region under the influence of global warming. The cores also contain evidence of probable past earthquake events. This 10,000-year record will significantly improve seismologists' confidence in forecasting the frequency of such seismic activity of infrequent (every 500 years) larger earthquakes in the region.

## Coal and the environment

A project is underway to trace the distribution of potentially hazardous pollutants linked to coal usage by looking at atmospheric emission and precipitation in the vicinity of power plants. It will also look at the abundance and distribution of these elements in water associated with *in situ* coal beds. Results will be related to possible health problems in the population centres in the study areas, which now include Alberta and Nova Scotia. The goal is to produce a database of distributions associated with Canadian coals. This will be used by Environment Canada for their utility emissions inventory and to establish regulatory thresholds for the emission of hazardous air pollutants from power plants.

## LAW OF THE SEA

For several years, the GSC and Canadian Hydrographic Service have been collaborating to define the geographic extent of Canadian sovereign rights over resources of the seabed and sub-seabed beyond 200 nautical miles, in accordance with the provisions of Article 76 of the United Nations Convention on the Law of the Sea. Situated off the Atlantic and Arctic coasts, the regions that contain these claimable resources are potentially huge, with a total area approaching nearly that of Manitoba, Saskatchewan and Alberta combined.

Implementing Article 76 requires a comprehensive knowledge of bathymetry, morphology, and sediment thickness in the deep waters off Canada's eastern and northern margins. Accordingly, the activity has prompted a substantial effort to assemble, rationalize, and analyze data sets that describe the relief of the seafloor and the distribution of the underlying sedimentary material.

Organized specifically for the purpose of determining the outer limit of resource jurisdiction, this body of information is expected to be extremely useful in a variety of other mapping and research activities where knowledge of the shape and composition of the seabed is essential. Some examples would include selecting pipeline and cable routes, modeling the circulation of bottom currents, understanding sediment transport, and studying the effects of glaciation and sea level changes.

### 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  
Geological Survey of Canada  
7 Observatory Crescent  
Ottawa, Ontario K1A 0Y3  
Telephone: (613) 992-0758  
Fax: (613) 992-8836

### Paleontology Services

GSC paleontologists and laboratory facilities are available nationally and internationally for a wide variety of cost-recovery and collaborative activities that conform to existing capabilities, on a case by case basis. These include fossil identifications and interpretations, laboratory preparations, referrals of paleontological samples 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.

For information contact:

T. P. Poulton  
Geological Survey of Canada  
3303 - 33rd Street N.W.  
Calgary, Alberta T2L 2A7  
Tel: (403) 292-7096  
Fax: (403) 292-6014  
E-mail: poulton@gsc.nrcan.gc.ca



*Geocryology is the study of frozen ground, its properties, and behaviour. With more than 50% of Canada underlain by permanently frozen ground, it is not surprising that Canada is a world leader in this field. The GSC is home to this research in the federal government.*

**Permafrost**

GSC permafrost expertise and advice is applied to many land-use, environmental and regulatory issues. Permafrost can be a naturally hazardous condition to structures built upon it as thaw may lead to instability and loss of support. Under certain conditions it is conducive to frost heave and the formation of ice, both of which can have an impact on foundations of buildings and pipelines. The thaw of the ice can affect the ability of permafrost to contain the movement of contaminants.

Gas hydrates, an ice-like compound with large volumes of gas molecules, can occur in permafrost. While they represent an enormous potential energy source in Arctic Canada, gas hydrates can pose a hazard to conventional oil and gas exploration and could represent a significant greenhouse gas if released.

**Glaciology**

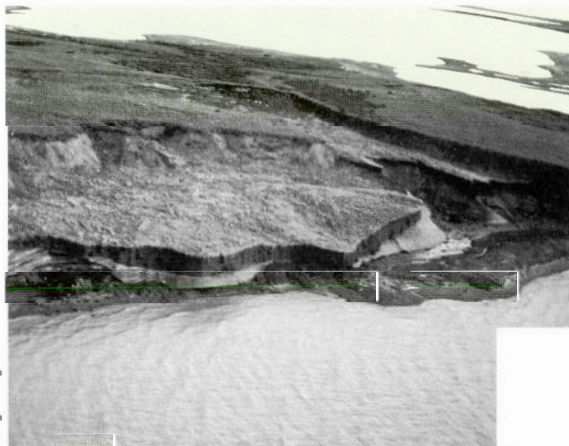
There is increasing interest in glacial records as they pertain to issues of global warming and pollutants in the environment. The world's ice caps are the cold trap for all atmospheric processes and as such contain a frozen layer-by-layer record of past temperatures, accumulation rates, summer melting, microparticles, pollen, chemical constituents, organic molecules, micro-organisms and paleo-air bubbles that contain old atmospheric gases. The information gleaned from ice cores has revolutionized our understanding of the Earth's recent (100,000 years) climate.

The goals of GSC's program are to understand climate and other environmental changes of the past as well as the rate of change, and place human perturbations into this context. New technologies, including ice-core drills and an ice-core analyzer, have been designed and produced by the GSC and our industrial partners. These instruments are now being marketed internationally.

*Some highlights of GSC's geocryology research:*

**NEW GEOCRYOLOGY RESEARCH FACILITY OPENED**

In the spring of 1996, the GSC and Ottawa-Carleton Geoscience Centre created the Geocryology Research Facility. This operation brings together equipment and expertise, some of it unique in Canada, from GSC and Carleton University in support of fundamental geocryological research, including the nature and behaviour of frozen soils and gas hydrates, and groundwater and soil remediation programs in cold regions. Collaborative work with Russian researchers successfully developed and tested two fully instrumented gas hydrate test cells. A series of tests are determining the permeability of frozen sand to organic contaminants.



Margo Burgess

**MASSIVE GROUND ICE, NEAR TUKTOYAKTUK, NORTHWEST TERRITORIES.**

## CONTAMINANTS IN FROZEN SOILS

In collaboration with Indian and Northern Affairs and the territorial government, the GSC conducted field investigations of reclaimed contaminated mine tailings at Rankin Inlet, Northwest Territories. The study is the first detailed *in situ* examination of the thermal, geophysical and geochemical behaviour of mine tailings during freezeback in a permafrost environment. The field work will be complemented by controlled environment laboratory testing at the Geocryology Research Facility to study the mechanics of contaminant transfer in permafrost. Field investigations of three abandoned drill sumps from hydrocarbon exploration wells in the Mackenzie Delta were also undertaken to determine whether seepage of drilling brines has occurred and to map the extent.

## PERMAFROST AND DIAMOND MINES

Permafrost is a critical element of the tailings design and management plan of the recently approved BHP diamond mine. Massive ground ice in glaciofluvial materials affects their use and stability for design and construction of mining infrastructure, and limits their availability as a source of construction materials. In the fall of 1996 the Northwest Territories Water Board sought GSC expertise to review permafrost aspects related to issuing the water licence

for the mine. Technical advice was also provided to Indian and Northern Affairs concerning the environmental agreement with BHP.



Paul Erickson

THE GSC ICE CORE DRILL IN ACTION ON THE DEVON ICE CAP UNDER THE INTERESTED EYES OF STUDENTS, THE MAYOR AND ELDERS FROM GRISE FIORD. THE VISITORS RECEIVED SAMPLE CORES AND A POSTER IN INUKTITUT TO TAKE BACK FOR CLASSROOM STUDY AS PART OF AN OUTREACH PROGRAM IN THE EASTERN ARCTIC.



Margo Burgess

GSC STUDIES THE INTERACTION BETWEEN PIPELINES AND PERMAFROST SOILS, AND THE RESULTING PIPE MOVEMENTS AND ASSOCIATED STRAINS. A SECTION OF THE BURIED NORMAN WELLS PIPELINE HAS BEEN LIFTED ABOVE GROUND, WITH FROST HEAVE THE LIKELY CAUSE.

## INTERNATIONAL GAS HYDRATE RESEARCH PROJECT

GSC's world leadership in gas hydrate studies was underscored by an agreement reached this year with the Japan National Oil Company, the Japan Petroleum Exploration Company and the U.S. Geological Survey to drill a gas hydrate exploration well in the Mackenzie Delta. Research will include state-of-the-art coring, geophysical well logging, seismic surveys and production testing of hydrate horizons. The project has the potential to appraise the economic potential of Arctic gas hydrates and will provide first-hand knowledge of the distribution of hydrates in nature. In addition to better resource and hazard assessments, the project should have an important impact on Canadian energy and environmental policy.

## GSC/INDUSTRY PERMAFROST INSTRUMENT EN ROUTE TO MARS

A U.S. space mission in 1998 will explore permafrost conditions in the southern polar regions of Mars. On board will be a thermal mass analyser initiated by GSC and its industrial partner, Icefield Instruments of Canada. The instrument will study near-surface permafrost conditions on Mars. Such projects have large potential benefits for the partner companies in terms of development of robust, miniaturized instrumentation, access to new technologies and materials, and some positive public relations opportunities. This success story will continue as GSC glaciologists have been asked to contribute to a potential future glaciology and climate history study of the polar ice caps of Mars.



# International Connections

*Canada is a recognized world leader in the geosciences and this "Made in Canada" expertise is much in demand. GSC's wide-ranging international activities bring a multitude of benefits to both Canada and the partner countries.*

By working abroad Canada's geoscientists are exposed to geological phenomena that may have important implications for Canada in mineral and petroleum exploration and development, natural hazard risk assessment, and environmental studies. International contacts are also a vehicle for Canadian industry to develop and market its expertise and equipment in other parts of the world. Finally GSC scientists contribute to responsible global sustainable development practices by assisting other countries in developing resources in an environmentally and socio-economically acceptable manner.

## SOUTH KOREA SIGNS ON TO OCEAN DRILLING PROGRAM

South Korea became a member of the Canada-Australia Ocean Drilling Program consortium with the signing of an agreement, August 6, in Australia.



Yvon Maurice

GSC STAFF PROVIDED TRAINING IN THE USE OF GROUND PENETRATING RADAR (GPR) AND GAMMA RAY SPECTROMETRY (GRS) TO THE BRAZILIANS. THESE ARE USEFUL FOR EXPLORATION PURPOSES AND TO MONITOR HAZARDOUS MATERIAL DISPOSAL SITES. BUSINESS OPPORTUNITIES FOR CANADIAN SERVICE AND EQUIPMENT SUPPLIERS WERE AN OFFSHOOT OF THIS INITIATIVE.

## ARGENTINA USING CANADIAN GEOSCIENCE MODEL

The GSC is working to enhance the capabilities of the Argentine federal government geoscience agency SERGEMAR. Funded by the World Bank, GSC in cooperation with Canadian private sector consultants, is training SERGEMAR staff in the proper collection and processing of geochemical samples and in the interpretation of analytical results. The GSC is also advising on 19 mineral deposit studies and giving instruction on handling contracts for airborne geophysical surveys.

## SUSTAINABLE DEVELOPMENT PRACTICES APPLIED IN BRAZIL

In cooperation with CIDA, NRCan scientists worked with Brazilian colleagues to promote sustainable development and socio-environmentally responsible use of Brazil's vast mineral resources. The GSC and Geological Survey of Brazil focused efforts on the collection of basic ecological and geological information in socially and environmentally stressed areas such as the Tapajós region of the Amazon Basin. Immediate social benefits to the region will be realized as mining practices change from the environmentally hazardous, artisanal methods to controllable and sustainable hardrock mining.

#### MULTINATIONAL ANDEAN PROJECT

In the summer of 1996, the Canadian International Development Agency (CIDA) approved this GSC-coordinated, four-year, \$4.8 million project. The project will assist the national geoscience agencies of Argentina, Bolivia, Chile and Peru in mapping portions of their shared border areas in the Andes Mountains. An important first step involved the sharing of GSC expertise. An Argentinean geologist spent a month at the GSC learning about applications of GIS and remote sensing technology to regional geological mapping. A Chilean geologist spent a month in the GSC radiometric lab learning about modern argon dating methodology. Two GSC geologists accompanied South American geologists in the field and held training sessions on field mapping techniques, structural geology and mineral deposits.

#### NUCLEAR TESTING TO BE MONITORED WORLDWIDE

As part of Canada's contribution to the Comprehensive Test Ban Treaty, which bans nuclear testing and has been signed by 140 countries, the GSC contributes seismic data from nine seismograph stations and the Yellowknife Array to a worldwide prototype International Monitoring System (IMS). GSC staff are also heavily involved in discussions about the design and standards for the IMS, sharing expertise garnered from almost 40 years of operating the Canadian National Seismic Network. If the IMS works as planned it will be able to pick up a nuclear blast anywhere on the planet and pinpoint its location to within 20 km of the explosion – a major technical achievement. The IMS also includes instruments that will detect pressure waves caused by submarine nuclear explosions. The GSC prototype is operating in the Queen Charlotte Islands, and its data are already in use.

#### CANADA/U.S. MAPPING PROJECT

A collaborative project involving the GSC, U.S. Geological Survey and other agencies in Russia, Alaska and Japan produced a series of eight geological maps of the circum-North Pacific region. These were released as on-demand GSC Open Files. The next and last phase of the project will be to produce a CD-ROM version of the digital data used to produce the maps.

#### WORLD BANK CONTRACT IN GUINEA

The World Bank awarded GSC a half million dollar contract to supervise a major geoscience initiative in Guinea. The project, which pulls together geophysics, geology and GIS, is intended to improve the geoscience infrastructure of the country, particularly for exploration purposes. Canadian industry is one of Guinea's largest investors in mining exploration. A Canadian geophysical contractor won the \$1.25 million contract for acquisition of aeromagnetic and radiometric data. GSC scientists assisted the Guineans in the design of the surveys and will guide interpretation of the geoscience data.


#### TECHNOLOGY TRANSFERS TO AFRICA AND ASIA

A three-year technology transfer program to a number of countries in East Africa is nearing completion. GSC staff subcontracted an array of organic geochemistry reviews, analyses and interpretations through a cooperative research agreement with a Canadian consulting company. Petroleum source potential and oil-source rock systems were examined in South Africa, Mozambique, Tanzania, Kenya, Ethiopia, Seychelles, Mauritius and Madagascar with the intention of establishing sufficient baseline data in a comprehensive report to attract investment by petroleum exploration and development companies from Canada and around the world.

#### OFFSHORE MINERALS SURVEY IN SRI LANKA

The GSC, at the request of the United Nations Revolving Fund for Natural Resources Exploration, carried out a nearshore survey for heavy minerals off the coast of Sri Lanka. In a collaborative venture with Canadian industry, the team utilized Seistec, a Canadian seismic reflection system ideally suited to image coarse sediments in shallow water. The survey, which was fully cost recovered, achieved its goals of mapping potential economic deposits and identifying sites for future core sampling and resource evaluation.





GSC'S SCIENTIFIC OUTPUT is made available to clients using a broad variety of delivery mechanisms, ranging from traditional publications and staff talks to the latest in digital GIS-based maps and interactive access on the Information Highway.

The Earth Sciences Information Centre (ESIC) provides clients with a single contact point, integrating traditional library-based services with the development and marketing of new, technology-driven information products and services.

## Information

### Synthesizing the sedimentary geology of northern mainland Canada

The systematic geological characterization of Canada's northern mainland frontiers reached a milestone with the publication of two major synthesis volumes. The *Geological Atlas of the Beaufort-Mackenzie Basin* (GSC Miscellaneous Report 59) contains the maps, cross sections and correlations charts required for a comprehensive synthesis of the regional stratigraphy, structure and petroleum geology of this important resource domain. Central to the synthesis are seismic and paleontological data and interpretations that allow for true three- and four-dimensional imaging of the geometry and time relationships embodied in the strata.

The second volume, *Geology and Mineral and Hydrocarbon Potential of Northern Yukon Territory and Northwestern District of Mackenzie* (GSC Bulletin 422), draws together geological data and interpretations gathered by

the GSC back to the Operation Porcupine work of the 1960s. Complementing these two syntheses, and currently under compilation, is a geological atlas of the remaining mainland sedimentary domains north of 60°, to be published in the year 2000.

### First Internet release of GSC geological map

In a pilot project to evaluate future digital map distribution, the GSC made the new *Surficial Materials of Canada* map available in three GIS formats from a GSC Website. Users are required to complete a brief questionnaire about client needs before downloading the files. After six months, more than 300 "customers" had been served, representing a world-wide audience of users in the private and public sector. The GSC now has a representative database on the needs and technical capabilities of the users of geological maps. It has also worked many of the "bugs" out of this type of map distribution. Website: [sts.gsc.nrcan.gc.ca/page1/sgm/maps.htm](http://sts.gsc.nrcan.gc.ca/page1/sgm/maps.htm)

## New B.C. bedrock maps have diverse applications

Bedrock mapping programs in the Canadian Cordillera continue to enhance client interaction. A new cooperative venture with the B.C. Geological Survey has made the Vernon map sheet, a GSC field project currently underway, accessible on the WWW to clients. This region is an exploration target for volcanogenic massive-sulphide-type deposits. Forestry companies are using the data to meet their obligations under new provincial forest practices legislation. Another GSC map of the Queen Charlotte Islands was used to update the provincial mineral inventory status of the region.

## Atlantic Canada maps: coming soon

The tectonic and geophysical features of Atlantic Canada are featured in a new series of 1:3,000,000 scale maps being produced by GSC scientists and academic colleagues. The first four (tectonics, magnetics, gravity, and morphology) are scheduled for release in mid-1997 as GSC Open Files. For information about this series, contact: Sonya Dehler, telephone (902) 426-4289, fax (902) 426-6152.

## EARTHNET: an online resource for teachers

The GSC, in conjunction with several professional geoscience associations, is spearheading a new online service that will help teachers find earth science resources for use in their classrooms. EARTHNET's searchable database will run the gamut of earth science topics. Each resource description will cover content and availability. Most important, teachers will be encouraged to add their evaluation of the resource and any lesson plans they have developed from it. EARTHNET's goals are to encourage use of existing earth science resource materials and promote a dynamic forum for teachers to discuss earth science education.

Visit the EARTHNET Website at:  
[agcwww.bio.ns.ca/schools/esrc/esr-home.html](http://agcwww.bio.ns.ca/schools/esrc/esr-home.html)

## GSC co-sponsors international symposium

*The Earth System: Geology Lessons for Our Future* symposium, held at the Ontario Science Centre in Toronto, December 5 to 7, 1996, was well received by over 300 teachers, students, scientists and media who attended. Dr. Richard Grieve, a GSC meteorite impact specialist, was one of 30 international experts invited to speak. His talk stressed that "Extraterrestrial Impacts" are continuing, albeit random, geological processes that have influenced crustal evolution, have had periodic marked consequences for life on earth, and have been responsible for the emplacement of some major ore deposits. The GSC was a major sponsor of the event.

## Logan Legacy Fund

The Logan Legacy Fund supports conservation work on archives held by the Earth Sciences Information Centre (ESIC). The Canadian Geological Foundation established the fund in 1992 to commemorate GSC's 150th anniversary. The 1996 fundraising campaign raised over \$11,000 from 69 donors, including three donors of \$1,000. Several books from ESIC's Book and Map Archives were conserved and rebinding of the large collection of original *Palaeontographica* volumes continued. Donors were honoured at a ceremony, April 14, 1997.



Communicating the results of GSC's work to a broader, non-technical audience is a priority. The goals are to increase public awareness of science and the contribution made by the GSC, to alert Canadians to the information available to them, and to encourage students to consider the geosciences as a career option.



## The geology of Canada's mountain parks

A new GSC public outreach program will produce geological maps of National Parks in the Rocky Mountains. They will provide a simplified compilation of the geology, complete with text and illustrations suitable for park visitors. Compilation began for Yoho National Park, where the famous Burgess Shale fossils are found. Future plans include geological maps of Banff, Jasper, Kootenay and Waterton Lakes national parks.

## LANDMARK MAP ON CANADA'S GEOLOGY

*The GSC has updated its popular Geological Map of Canada, first published in 1869 and last published in 1969. The 1:5,000,000 scale wall map describes bedrock formations at or near the surface of the land. It was created using new technology, new information, and improved methods of dating and correlating geological units. The GSC used sophisticated cartographic technology to integrate its gravity, aeromagnetic, marine and geoscience data with that from the provinces, territories and other sources.*

*New to this edition, the map shows how the bedrock formations extend across the Great Lakes and on the seafloor, and it displays the age, structure and patterns of oceanic crust surrounding Canada.*

*Other additions include the locations of major faults, kimberlite pipes, meteorite impact structures and areas of submarine volcanism.*

*To order in paper or digital formats, see page 38.*



## Geological Map of the World goes digital

The GSC sent a Beta release CD-ROM of the *Generalized Geological Map of the World* to industry partners who contributed to data compilation and preparation of this series of 1:35,000,000 scale maps. The Beta release includes geological, geophysical and mineral deposit data and images in formats designed for easy integration into a variety of GIS systems, or for direct viewing and interpretation. Canadian and foreign mining companies have subscribed to the project, which will eventually produce maps and databases for such mineral commodities as copper, gold, nickel, uranium and others. It will also include geological thematic layers including seafloor geology, mafic and ultramafic rocks and global tectonic plate boundaries.

## GeoExpress: a great new connection

GeoExpress facilitates public access to digital maps and other geospatial information. Based on the voluntary participation of suppliers, including government agencies and industry, GeoExpress works like a switchboard operator. It connects the user with available geospatial information suppliers. Once the user has selected a supplier, they proceed on the basis of rules of access (e.g., pricing) and level of service that apply between them. Visit the Geoexpress Website at [nrcan.gc.ca/geoexpress](http://nrcan.gc.ca/geoexpress)

## GSC via the Links

GSC-Links make access to GSC information easier for clients. Located at the Ontario Mines and Minerals Information Centre in Toronto and at the Manitoba Department of Energy and Mines in Winnipeg, GSC-Links are a computer terminal linked to the GSC gopher and a display of current releases, maps and CD-ROM products.

# SHRIMP

*Already a world-leader in the geochronology of the Earth's crust, the GSC now has the latest microprobe technology to apply in solving Canada's geological problems. The new 10-tonne Sensitive High-Resolution Ion Microprobe (SHRIMP) is one of only four of its type in the world, and the first in Canada.*

The SHRIMP allows isotopic ages to be determined from tiny spots in single crystals, without chemical pretreatment. The SHRIMP dating method is non-destructive. It is ideal for imaging and contextual studies, allowing scientists to gain a better understanding of geological processes such as partial melting, metamorphism, and mineralization. SHRIMP dates mineral samples in a fraction of the time required by other equipment.

SHRIMP allows dates from samples to be obtained that were previously unobtainable and is a significant research advantage to Canadians.

## SHRIMP BUSINESS PLAN

The SHRIMP is available to the Canadian and international geoscience community on a collaborative and cost-recovery basis. The business plan for the management, operation and fee structure of the SHRIMP is the result of consultation and consensus with external partners and clients. The SHRIMP's operation will be a proposal-driven process, reviewed by an advisory board with representatives from government, industry and the universities.

## SHRIMP DATES OLDEST ROCKS ON EARTH

Using the SHRIMP, GSC researchers were able to definitively confirm that gneissic rocks from the northwestern Canadian Shield are the oldest yet dated on Earth. The rocks from the Acasta Gneiss are up to 4.02 billion years old.

The GSC initiated a systematic evaluation of the geology and geochronology of these complex gneisses, building on previous ground-breaking work that revealed the presence of gneisses at least as old as 3.96 billion years. This work advances our understanding of the evolution of the ancient crust and relates its development to the main portion of the Slave Geological Province.



GSC

**THE J.C. RODDICK ION MICROPROBE LABORATORY WAS OFFICIALLY OPENED OCTOBER 1996 BY DR. MARC DENIS EVERELL, ASSISTANT DEPUTY MINISTER, EARTH SCIENCES SECTOR.**



Sue Roddick

**DR. CHRIS RODDICK**

DR. CHRIS RODDICK, WHOSE KNOWLEDGE AND EXPERTISE LED THE GSC TO INVEST IN AN ION MICROPROBE, DIED TRAGICALLY IN A SKIING ACCIDENT BEFORE BEING ABLE TO TAKE CHARGE OF THE SHRIMP FACILITY AND ITS EXCITING RESEARCH.



The Geological Survey of Canada publishes its research in many scientific journals and commercial publications. It also has an in-house publishing capability and sells both print and digital products. The Earth Sciences Information Centre provides a reference service to the complete output, including GSC's extensive annual map production. A selection of priced products published by the GSC in 1996-97 follows.

## GEOLOGICAL MAP OF CANADA

*Compiled by J.O. Wheeler*

Only the third such compilation since Sir William Logan's original map of 1869, this landmark map presents the latest understanding of Canada's geology. It reflects new interpretations of Canada's geology resulting from recent geological mapping, extensive aeromagnetic and gravity surveys, and improved methods of dating and correlating geological units. Offshore geology (across the Great Lakes and the oceanic crust surrounding Canada) is one of many new features. Available in various formats.

*GSC Map 1860A. Bilingual map with English or French legend, \$30.00 in Canada; \$39.00 outside Canada. Bilingual map with English legend and French legend, \$40.00 in Canada; \$52.00 outside Canada. Bilingual CD-ROM, \$100.00 in Canada; \$130.00 outside Canada.*

## SURFICIAL MATERIALS OF CANADA

*Compiled by R.J. Fulton*

Following on last year's paper version, this digital data release has geology, landforms and hydrography on separate layers in .DXF, .MIF, or .E00 formats. The accompanying metadata include the bibliographic file (GSC Open File 3046) containing references to the published maps that were used in the compilation.

*GSC Map 1880A. \$15.00 in Canada; \$19.50 outside Canada. CD-ROM \$50.00 in Canada, \$65.00 outside Canada. Or at the Website: [sts.gsc.nrcan.gc.ca/page1/sgm/maps.htm](http://sts.gsc.nrcan.gc.ca/page1/sgm/maps.htm)*

## GEOLOGY OF CANADIAN MINERAL DEPOSIT TYPES

*Edited by O.R. Eckstrand, W.D. Sinclair and R.I. Thorpe*

A summary of the essential characteristics of all economically significant Canadian metallic and some industrial mineral deposits, this book is a comprehensive reference for earth scientists, explorationists, students and others interested in mineral deposits. This best-seller is part of the *Geology of Canada* series and is produced under the Geological Society of America's Decade of North American Geology (DNAG) project.

*\$70.00 in Canada, \$91.00 outside Canada.*

## SEARCHING FOR DIAMONDS IN CANADA

*Edited by A.N. LeCheminant, D.G. Richardson, R.N.W. DiLabio, and K.A. Richardson*

Discovery of world-class diamond deposits depends on determined mineral exploration aided by a reliable and comprehensive geological database. This volume provides a snapshot of the spectrum of geoscience information available to assist diamond exploration in Canada. Maps provide ready access to data acquired and interpreted by GSC, provincial surveys and university researchers.

*GSC Open File 3228. \$40.00 in Canada, \$52.00 outside Canada.*

## PRINCIPAL MINERAL AREAS OF CANADA

The 46th edition of this classic reference at a scale 1:6,000,000.

*GSC Map 900A. One copy free of charge to residents of Canada. Extra copies \$7.50 in Canada, \$9.75 outside Canada.*

## EXTECH 1: A multidisciplinary approach to massive sulphide research in the Rusty Lake-Snow Lake greenstone belts, Manitoba

*Edited by G.F. Bonham-Carter, A.G. Galley, and G.E.M. Hall*

EXTECH, a GSC program launched in 1989, promotes new approaches to base metal exploration with the goal of extending the life of Canadian mining districts. The integration of geology, geophysics, and geochemistry in EXTECH I has stimulated exploration in this area.

*GSC Bulletin 426. \$46.55 in Canada, \$60.50 outside Canada.*

## PALEOSEISMOLOGY AND SEISMIC HAZARDS, SOUTHWESTERN BRITISH COLUMBIA

*Compiled and edited by J.J. Clague*

The destructiveness of earthquakes at Los Angeles in 1994 (US\$26 billion damage) and near San Francisco in 1989 (US\$10 billion damage) underscores the need to better understand the causes and effects of earthquakes in British Columbia. This report presents evidence for large prehistoric earthquakes in southwestern B.C. based on an investigation of the geological record and provides an improved understanding of the seismic hazard in the region.

*GSC Bulletin 494. \$18.55 in Canada, \$24.10 outside Canada.*

## PRELIMINARY PALEOGEOGRAPHIC MAPS OF GLACIATED NORTH AMERICA

*By A.S. Dyke*

These time-slice maps show the evolution of various aspects of the North American landscape from 18,000 to 1,000 years ago. They include patterns of lake sedimentation, marine mollusc zones, periglacial features and alpine glacier fluctuations, fossil mammal assemblages, wetland and eolian features, and crustal movement associated with removal of ice sheets. The maps are critical for paleoenvironmental reconstructions and illustrate how geoscience information is important in estimating the severity and rates of possible climate change.

*GSC Open File 3296. \$90.00 in Canada, \$117.00 outside Canada.*

## Popular Reading

**ENCOUNTERS**, co-published by General Store Publishing House and the GSC, is a richly illustrated 120-page book containing a wealth of rare early images of Canada's aboriginal peoples from the GSC photo archives. It also includes a comprehensive bibliography. *Available from GSC Bookstores or General Store Publishing House at 1-800-465-6072. \$18.95 in Canada, \$24.65 outside Canada.*

**GEOSCAPE VANCOUVER** is a 90 by 150 cm, full-colour poster with over 30 diagrams, photographs and maps. It tells the story of earthquakes, volcanic eruptions, landslides, avalanches, floods, groundwater contamination, safety of the drinking water supply, and earth resources throughout southwestern British Columbia. Geoscape Vancouver is of particular application for educators and professionals in a wide range of fields. *Available from the GSC Bookstore in Vancouver (see inside back cover) for \$15.00 in Canada, \$19.50 outside Canada.*

**L'ÉCHELLE DES TEMPS GÉOLOGIQUES = 4 550 MILLIONS D'ANNÉES D'HISTOIRE** The Earth's 4.5 billion years of history is difficult for most people to imagine. This poster helps by compressing this immense period of time into a twelve-hour scale, in which a thousand years corresponds to just a few seconds. In the total history of the planet, the advent of humans barely appears in the final few minutes. *Available (French only) from the Québec Geoscience Centre for \$5.60 in Canada, \$7.30 outside Canada.*

**NATURE WELLS GRAY** is a richly illustrated guidebook to the rocks, waters, forests and wildlife of Wells Gray Provincial Park, in a wilderness area 160 km north of Kamloops, British Columbia. Written by Trevor Goward and Catherine Hickson, *this book is available (English only) from the GSC Bookstore in Vancouver (see inside back cover) for \$14.95 in Canada, \$19.44 outside Canada.*

## ORDERING INFORMATION

*Unless otherwise indicated, publications and CD products may be ordered from the GSC bookstore in Ottawa or from our regional offices in Sainte-Foy, Calgary and Vancouver (see inside back cover for addresses). Prepayment is required by cheque or money order made out to the Receiver General of Canada. VISA and Mastercard are accepted. All prices listed are in Canadian dollars, and are subject to change without notice. Applicable taxes and shipping and handling costs are extra.*

### EARTH SCIENCES INFORMATION CENTRE

ESIC has Canada's largest collection of books, journals and maps on the earth sciences with worldwide coverage. It offers clients on-line access to the library holdings (two million items), the federal geoscience database GEOSCAN, and a scientific and technical inquiries service. ESIC collections also include photos, GSC Open Files, CD-ROMs, videos, technical reports and audio tapes.

Many of ESIC's services and products can be accessed through the World Wide Web. Some fees for document delivery and reference services apply to external clients. For a brochure or more information, contact the Information Desk at (613) 996-3919. Access to the library Union Catalogue (information on the holdings of ESIC and the GSC regional libraries) is available through modem (613) 947-5722 or the ESIC Home Page: [www.nrcan.gc.ca/ess/esic/esic\\_e.html](http://www.nrcan.gc.ca/ess/esic/esic_e.html)



## 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 analyzed 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 - SURFICIAL GEOCHEMISTRY

This laboratory focuses 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 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 Quebec isotopic geochemistry laboratory analyzes stable isotopes of hydrogen, carbon, nitrogen, oxygen and sulphur using PRISM-VG, Isotech, SIRA-12, GC-COMBUSTION-Prism, auto-water for oxygen, and elemental analyzer 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 analyzing the isotopes of water, reagent hosts and dissolved components.

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## DENDROCHRONOLOGY AND DENDROGEOCHEMISTRY LABORATORY

This laboratory, which uses sequences of growth rings in trees as bioindicators of natural and anthropogenic environmental disturbances, includes a high-precision (0.001 mm) Unislide micrometer and Metronics Inc. QC-1000 acquisition system for computer data transfer. In particular, this system permits the production and statistical processing of tree growth patterns. Coupled with geochemical analysis, this technique makes it possible to reconstruct paleoenvironmental conditions and to determine the temporal evolution of contaminants.

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## GEOCHRONOLOGY LABORATORY

GSC's Geochronology Laboratory specializes in rock and mineral age dating and isotopic micro-analysis using U-Pb, Sm-Nd, Rb-Sr, and Ar-Ar isotopic systems. The laboratory has long been involved in the development of 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 state-of-the-art facilities are available to clients in Canada and abroad.

The latest addition to the laboratory is the Sensitive High Resolution Ion Microprobe (SHRIMP). One of only four facilities 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.

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## GEOCRYOLOGY RESEARCH LABORATORY

GSC and Carleton University have established an important new 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 divided bar apparatus used to determine thermal diffusivity and conductivity, 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 programs: geomagnetism, marine geophysics, crustal geophysics and seismology. For external clients, it undertakes calibration services for magnetometers, magnetic compasses, and magnetotelluric systems. Operational and scientific groups collect and use geomagnetic data from across Canada for a variety of purposes (e.g., production of magnetic charts for navigation by compass, magnetic storm warnings). Scientific and engineering collaborations with industrial and academic partners are welcomed. Research specialties include the effects of magnetic storms and related phenomena on modern technological systems such as electric power transmission and pipelines.

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## GEOTHERMICS LABORATORY

This laboratory specializes in measuring the thermal parameters of rocks: thermal conductivity and heat generation. A pulsed needle probe or a divided bar is used to measure the thermal conductivity of samples of rock fragments or solid rock. Passive gamma-ray spectrometry with Ge(Li) detectors is used to determine the heat generation in rock samples. A database containing heat generation data is maintained, and occasionally published as an open file. Amounts of radioactive Cesium in recent sediments, in order to date them, are also measured. Measurement accuracy is assured by frequent calibrations and the use of standards and worldwide interlab comparisons. Collaborators may visit the lab to carry out supervised measurements.

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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 analyzed as macro and micro samples, using state-of-the-art and, in some cases, world-leading techniques, including laser-based fluorination of microscopic samples. The laboratory is also involved in the recalibration of the internationally accepted scale for sulphur isotope geochemistry. Collaborating scientists from government, industry and university typically 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 functions are imaging of microscopic geological materials such as microfossils, and imaging and chemical analysis 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. The ESEM is capable of examining unconsolidated marine sediment samples in a natural (wet) state for more accurate characterization of geotechnical properties such as porosity. The facility collaborates with external clients 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.

G.M. LeCheminant

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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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## MARINE EQUIPMENT RENTAL

The GSC has unique marine equipment which is available to external partners under certain arrangements. International requests for scientific collaboration often involve usage 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, Geoforce, so it could bid on a contract with the British Antarctic Survey to conduct surveys in the South Atlantic.

To explore possible connections, contact:

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**Ralph Currie**  
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## ORGANIC PETROLOGICAL 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 IBAS 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 (done on site) and measurement.

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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 DATING LABORATORY

The <sup>14</sup>C laboratory provides dating control for many of GSC's Quaternary mapping and environmental projects. As well, the lab sets national standards and maintains a Canadian <sup>14</sup>C database that may be consulted by Canadian or other researchers visiting the Ottawa laboratory facility. The laboratory will consider providing dating control for university researchers on a cost per sample basis, on a case by case basis.

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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 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, which 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 1996-1997 Expenditures (\$000's)

### GEOLOGICAL SURVEY OF CANADA

| Minerals and Continental<br>Geoscience Branch                                      | Salary  | Operating | Capital | Total             | Revenue,*<br>Cost Sharing |
|--|---------|-----------|---------|-------------------|---------------------------|
| <i>Director General</i>  | 190.6   | 40.8      | 2.1     | 233.5             |                           |
| <i>Continental Geoscience</i>  | 5693.0  | 4049.5    | 643.4   | 10385.9           | 2629.8                    |
| <i>GSC Pacific (Ottawa)</i>  | 2398.2  | 831.0     | 479.1   | 3708.3            | 128.9                     |
| <i>GSC Pacific (Sidney)</i>  | 2789.5  | 1516.4    | 431.4   | 4737.3            | 854.8                     |
| <i>GSC Pacific (Vancouver)</i>   | 2112.7  | 885.8     | 438.1   | 3436.6            | 706.5                     |
| <i>Mineral Resources</i>   | 6716.5  | 2101.8    | 1152.8  | 9971.1            | 1779.0                    |
| <i>Total</i>   | 19900.5 | 9425.3    | 3146.9  | 32472.7           | 6099.0                    |
| <b>Sedimentary and Marine<br/>Geoscience Branch</b>                                |         |           |         |                   |                           |
| <i>Director General</i>  | 161.4   | 97.2      | 9.6     | 268.2             | 4.1                       |
| <i>GSC Atlantic</i>  | 5566.4  | 3091.2    | 857.8   | 9515.4            | 629.8                     |
| <i>GSC Calgary</i>   | 6812.0  | 4493.6    | 960.9   | 12266.5           | 1406.2                    |
| <i>GSC Quebec</i>  | 1369.6  | 1248.8    | 461.4   | 3079.8            | 360.9                     |
| <i>Terrain Sciences</i>  | 4838.0  | 2361.8    | 469.5   | 7669.3            | 465.1                     |
| <i>Total</i>   | 18747.4 | 11292.6   | 2759.2  | 32799.2           | 2866.1                    |
| <b>TOTAL GSC</b>   | 38647.9 | 20717.9   | 5906.1  | 65271.9           | 8965.1                    |
| <b>GEOMATICS CANADA</b>  | 33075.1 | 28508.0   | 8676.6  | 70259.7           | 32777.7                   |
| <b>POLAR CONTINENTAL<br/>SHELF PROJECT</b>   | 742.5   | 4002.5    | 68.1    | 4813.1            | 3066.5                    |
| <b>CORPORATE SERVICES**</b>  |         |           |         |                   |                           |
| <i>Executive Services</i>  | 1693.4  | 704.1     | 68.5    | 2466.0            | 180.9                     |
| <i>Policy, Planning,<br/>Information and Services<br/>Grants and Contributions</i> | 8756.3  | 5143.5    | 1910.7  | 15810.5<br>2263.3 | 317.9                     |
| <i>Total Corporate Services</i>  | 10449.7 | 5847.6    | 1979.2  | 20539.8           | 498.8                     |
| <b>TOTAL SECTOR</b>  | 82915.2 | 59076.0   | 16630.0 | 160884.5          | 45308.1                   |

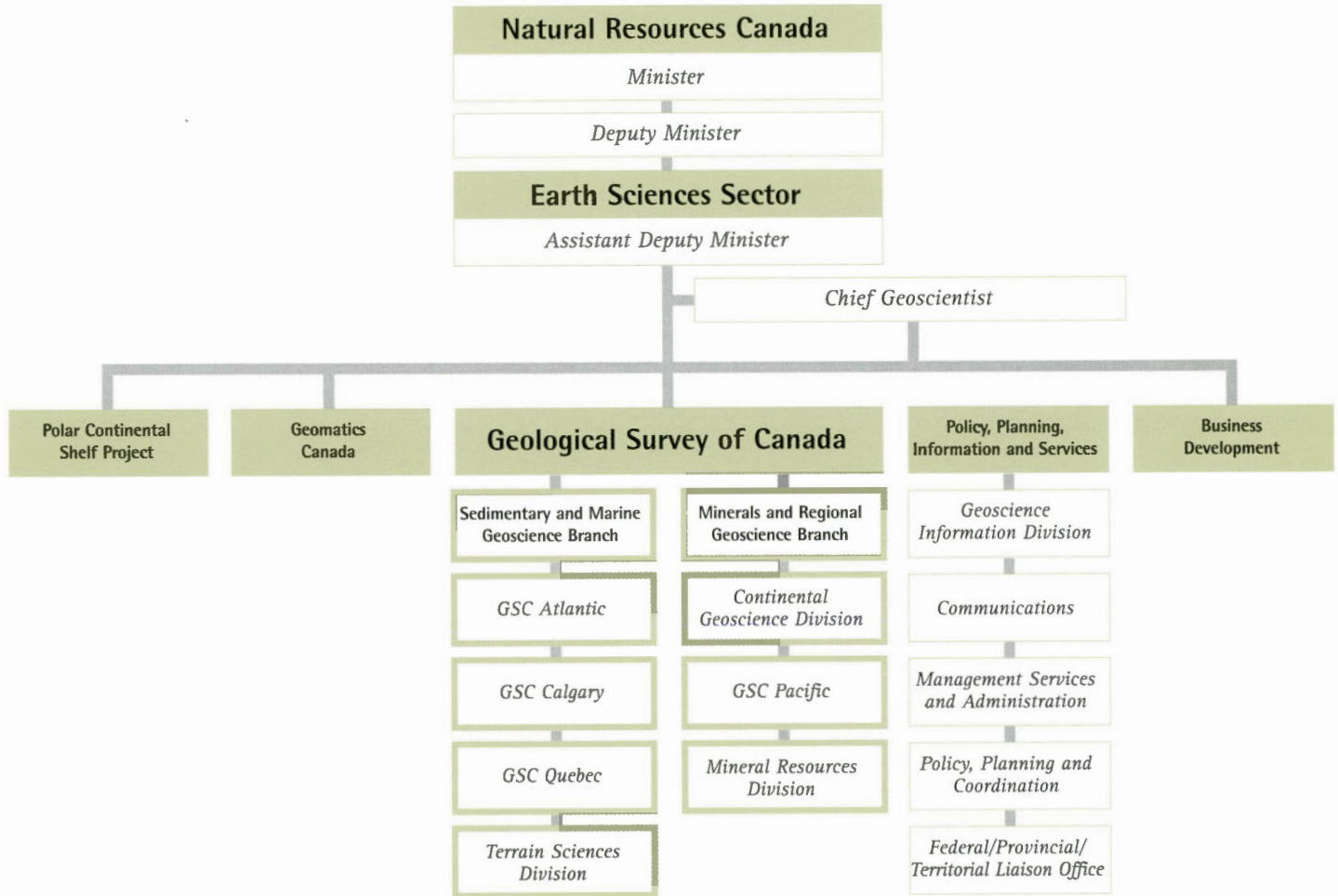
\* Includes additional funds from intellectual property, vote netted revenue, revolving fund, specified purpose accounts, and transfers from other government departments.

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





# Organization



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