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*Geological Survey
of Canada*



GEOSCIENCE
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2000-2001

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GEOLOGICAL SURVEY OF CANADA

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

Part of Natural Resources Canada, the GSC's mission is to provide Canada with comprehensive geoscience knowledge contributing to economic growth, sustainable development, health and safety, and environmental protection.

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

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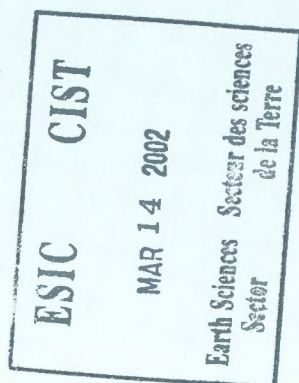
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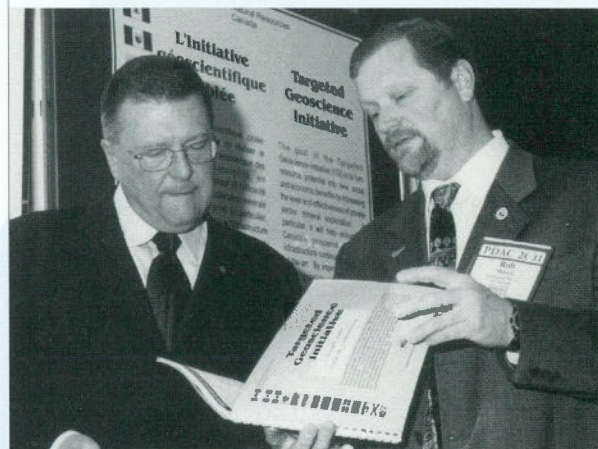
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Coming up diamonds

The Prospectors and Developers Association of Canada (PDAC) annual meeting in Toronto provides the GSC with an excellent opportunity to present its current research activities and cumulative research expertise to one of its major client groups: the mineral exploration and mining industry. The GSC display on diamonds and platinum group elements (PGEs) got rave reviews at the March 2001 PDAC. It included new models for the formation and emplacement of diamonds and their occurrence in Canada. New geological maps of ancient cratons where diamondiferous kimberlites may be found and geophysical and geochemical methods used for the detection of diamonds were also featured. Industry interest in PGEs was addressed with new compilations of Ni-Cu-PGE deposits and occurrences for several provinces and the presentation of GSC mapping results in areas of known mineralization in the N.W.T, Yukon, Ontario and Saskatchewan.



Minister Goodale and GSC scientist Rob Shives discuss the Targeted Geoscience Initiative at the Prospector and Developers Association conference, where it was featured as part of the NRCan exhibit.

A Message from the Minister



Natural Resources Canada (NRCan) gives Canadians an increasingly comprehensive picture of our country's natural resources by finding, measuring and mapping these resources. This role has evolved with the times. Canadians now depend on the expertise of our key geoscience organization, the Geological Survey of Canada, to deliver the information they need to make decisions that are economically, environmentally and socially sound. Over recent years, our focus has expanded to include research on earthquakes, landslides and climate change—phenomena that affect Canadians' safety and well-being.



Time and time again, NRCan has demonstrated a strong capability to put innovative technologies to work for the benefit of Canadians. The digital revolution, for example, has had a profound impact on the way scientific information is shared. We have responded by devoting considerable creativity, effort and resources to hone digital capabilities and applications so that we can deliver our science digitally. The goal? At the click of a mouse, Canadians will have immediate access to high-quality geoscience about Canada.

The Targeted Geoscience Initiative, launched in June 2000, is proof of NRCan's work in action. To increase the level and effectiveness of mineral exploration in Canada, we are producing new geological maps and data about under-explored areas with a high potential for mineral deposits. These maps will guide companies to the most promising sites, thereby increasing the effectiveness and success of costly exploration efforts.

This year, NRCan is placing greater emphasis on a subject of growing public concern—groundwater. More than 30 percent of Canadians rely on groundwater for their water supply, and the health of our streams and ecosystems depends on it. We are leading a major research initiative involving the provinces and territories, municipalities, universities and the private sector to determine the location, size and characteristics of Canada's main aquifers, an important first step toward helping Canadians manage this vital resource sustainably.

As this year's report demonstrates, we continue to explore new areas of geoscience, giving the accurate information Canadians need to manage our resources wisely. By sharing ideas and adopting new technologies, NRCan continues to enhance Canada's international reputation for excellence in geoscience and proper stewardship of our natural resources.

The Honourable Ralph Goodale
Minister of Natural Resources Canada

Meeting new challenges with innovative solutions

A trademark of the GSC, from its founding in 1842, has been its success in adapting its programs to support the needs and priorities of Canada. That tradition continues as the GSC refocuses itself to meet the challenges of delivering science in today's complex world. A key initiative has been the adoption of four strategic goals that clearly link the GSC's output with Canada's social and economic needs. All GSC work must meet one of the following goals to provide geoscience that:

- supports sound economic, environmental and social decision-making;
- sustains economic benefits;
- minimizes impacts of natural resource development, other land uses and climate change;
- enhances the safety and economic security of Canadians.

The digital revolution is having a huge impact on all aspects of modern life. The entire international science community has been at the forefront of developing and honing digital capabilities and applications, and the GSC has been very much part of this activity. Much intellectual and creative effort, as well as resources, have been devoted by the GSC to this move into digital delivery of geoscience. A new federal Government OnLine office is supporting and coordinating efforts to ensure that GSC services are delivered online and that they respect government standards for accessibility and uniformity of presentation of scientific information. The pages that follow include a diverse range of new online services and tools available from the GSC.

The GSC is part of a nation-wide network of research groups in the provinces and territories, and in universities that provides Canada with the geoscience knowledge that it needs. As part of this dynamic and far-reaching network, the GSC has helped to further collaboration, partnerships, networking, and cost-sharing—all of which are increasingly essential to the successful delivery of geoscience for Canadians.

A new cross-Canada initiative for groundwater typifies how the GSC is applying these innovative solutions to a new challenge. Given the growing importance of Canada's strategic groundwater resources, the GSC has taken a lead role in setting in place a national partnership group that will shape future research directions across Canada. Results will be shared and delivered in a digital form. More details about collaborative groundwater programs can be found on the next page.

DID YOU KNOW?

The GSC website is a treasure house of scientific and educational information. It received over 8,000,000 hits this year.
www.nrcan.gc.ca/gsc

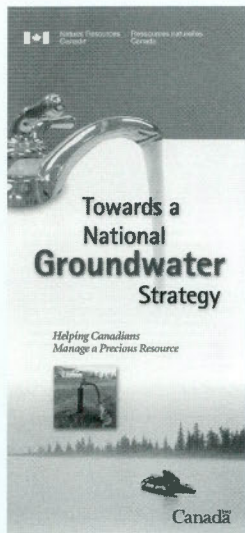
Groundwater: Geoscience supporting water management

Over 30% of Canadians rely on groundwater for their water supply, and the health of our streams and ecosystems depends upon it.

Groundwater is a renewable resource that requires wise management to protect its integrity and its sustainable development. There are, at present, major gaps in understanding groundwater. While it is known that Canada's surface waters represent 10% of the world's useable freshwater, the amount of available groundwater is unknown. More knowledge is needed on the number, size, characteristics and dynamics of Canada's main aquifers.

The GSC, with its expertise in regional mapping and geology, is well positioned to help develop this knowledge. The GSC has several regional-scale groundwater projects underway. Each project has strong involvement from universities and other federal and provincial government agencies, as well as from local stakeholders:

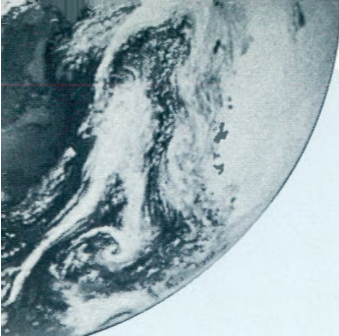
- The Oak Ridges Moraine project in the Greater Toronto Area has established methods for groundwater studies with application to aquifers across the country. Project impact on land-use planning across the moraine is linked to GSC maps, data protocols and field techniques. These have been adopted by many municipal groups for regional groundwater assessment and water resource planning. The project has opened doors to new partnerships, including a role in deliberations on Great Lakes issues.
- The Laurentian Piedmont project studied the aquifers of the St Lawrence valley, a major groundwater source for southern Quebec. Products from this completed project include information management tools and groundwater maps that show the geological context, and groundwater quantity, quality and vulnerability to contamination. The project also resulted in a transfer of a hydrogeological database to land-use planners in the regional municipalities of Portneuf.
- The Winnipeg project is designed to better understand the long-term viability of groundwater supplies in the carbonate and sandstone aquifers of the Winnipeg/Lake Winnipeg region. Groundwater use in the region is constrained by mobile saline waters to the west, and is reliant on adequate replenishment largely derived from the Sandilands Moraine. Knowledge gained will facilitate sustainable groundwater-reliant development, as well as management of the resource across the International Boundary and in local aboriginal communities.



Groundwater Online

The new website HYDROLINK
is the portal to GSC's
hydrogeology databases:

www.cgq-qgc.ca/hydrolink



National collaborative groundwater programs

The GSC is committed to building a strong national groundwater program in partnership with municipal, provincial and federal agencies, universities and industry. Consultations with these partners are well advanced. Through workshops and planning sessions, the goal is to develop a national strategic vision and action plan for providing the geoscience knowledge needed to support groundwater management.

A national workshop on groundwater, held in Quebec City in June 2000, was a significant step towards this goal. Participants identified major groundwater issues across Canada and explored various means for addressing them. Another important milestone was the signing of a groundwater resources agreement with Environment Canada, under which the National Water Research Institute and the GSC will work together on groundwater research of mutual interest.

- The St. Lawrence Lowlands fractured rock aquifers project is carrying out a large-scale groundwater mapping of four municipalities north of Montreal. It will develop protocols for regional mapping of fractured rocks, assess groundwater resources, quantify the sustainable safe yield, and provide knowledge that will support land-use planning and groundwater protection.
- The Maritimes Groundwater Initiative will improve understanding of groundwater flow dynamics within major aquifers in eastern New Brunswick, P.E.I. and northwestern Nova Scotia. It will provide baseline information for a regional groundwater resource assessment in support of groundwater management and protection. It will also address key issues related to saltwater intrusion and the impact of climate change on groundwater.
- The Prairie Groundwater Initiative, a joint effort of the GSC and ten other agencies, grew from the critical need to address issues of the sustainability of soils and waters in the great agricultural lands of the Prairies. It is providing new regional knowledge regarding the crucial groundwater supplies in the Prairies, including potential climate change impacts, and information required to manage and protect groundwater resources.

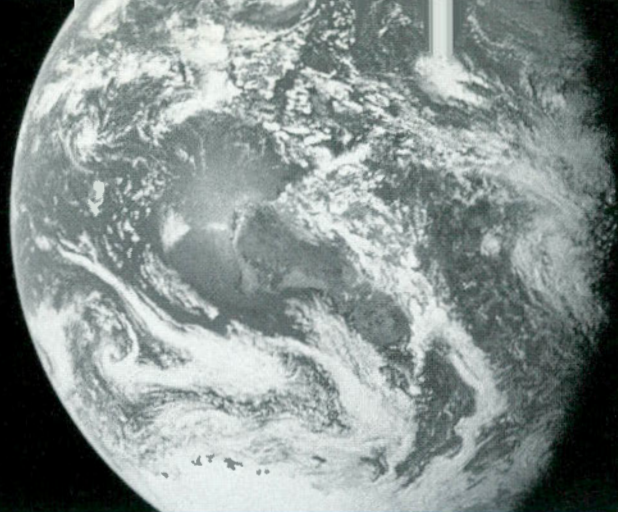
For more information, contact
Dr. Alfonso Rivera,
GSC Chief Hydrogeologist,
by telephone at (418) 654-2688
or by e-mail at arivera@nrcan.gc.ca.



Diane Lewis

An ad-hoc committee with representatives from a broad range of organizations from across Canada is coordinating the development of a national framework of collaboration for groundwater: from left, front row: Al Kohut, B.C. Ministry of Water, Land and Air Protection; Darryl Pupek, N.B. Environment and Local Governments; Nolan Shaheen, Saskatchewan Water; Maurice Lewis, Canadian Ground Water Association; back row: Allan Crowe, Environment Canada; Alfonso Rivera, GSC; Cam Baker, Ontario Geological Survey.

GEOSCIENCE SURVEYS



A comprehensive national geoscience knowledge base encompassing Canada's vast landmass and offshore territories provides the framework for mineral and petroleum exploration, groundwater resource management, land-use decision-making and many other applications. The knowledge base also contributes to understanding and preparing for natural hazards, particularly landslides, earthquakes, and climate change.

Ellesmere Island program completed

Fieldwork on northeastern Ellesmere Island was successfully completed in 2000, in collaboration with the BGR (German Geological Survey) which has contributed over \$400,000 to the project over the past three years. In the spring of 2001, the project partners met in Germany to develop a comprehensive publication plan. The project has already triggered significant scientific advances: the discovery of lead-zinc mineralization has led to two exploration programs by industry, and new information about the relative movement of Greenland against Ellesmere Island may have application to hydrocarbon resources in the Kane Basin.

GEOIDE Moose Mountain project

In collaboration with a team of university researchers, efforts to develop 3D digital integration methods for resource assessment continued under this three-year project. Work with Husky Oil, Shell Canada, Talisman Energy and the Canada Centre for Remote Sensing led to the development of methods for integrating geological, photogrammetric and remote sensing data that can be used for resource assessment in foreland thrust and fold belts. Moose Mountain, located west of Calgary in the foreland of the Canadian Cordillera, was selected as a natural laboratory for the methodology development. The project is funded by the Network of Centres of Excellence GEOIDE (GEOmatrics for Informed Decisions).

Aeromagnetic surveys

The GSC, supported by the Canadian exploration community, acquires high-resolution regional aeromagnetic data over many regions in Canada. Participants in the surveys benefit from cost-shared, high-quality acquisition, and from the expertise of GSC's aeromagnetic group, which has helped establish industry standards for the acquisition of aeromagnetic data. Recent aeromagnetic surveys in the Mackenzie Valley Corridor and northern Ontario are stimulating hydrocarbon and mineral exploration, as well as contributing to creating a world class Canadian airborne geophysical industry.

Western Canada Sedimentary Basin

In September 2000, representatives of the GSC and the geological surveys of the four western provinces formed the Western Canada Sedimentary Basin Committee, which includes representatives from industry and the National Energy Board as well. Its purpose is to share information on ongoing projects, develop priorities for future work and cooperation, and foster more partnership in research projects. The committee, which enhances existing bilateral government committees, will develop collaborative programs based on geological province boundaries. It will meet annually to consider priorities and cooperation.

**A Society of Exploration
Geophysicists publication stated
"The Canadian government surveys
are some of the highest quality
published magnetic maps in
the world".**

Fossil fungi: an exploration tool

An industry-supported evaluation of the world's fossil fungi resulted in a major publication: *Synopsis of fungal spores, mycelia and fructifications*. The importance of the lowly fungi lies in providing a biostratigraphic framework, including the geological age of rock formations, correlations and environments of deposition for the sedimentary rocks in which they occur. Their abundance in deltaic and estuarine environments, where other fossils are poorly represented, makes them of interest to the petroleum industry, which initially developed the expertise. Certain characteristic forms, which still exist in tropical and sub-tropical settings, are found in Tertiary rocks of the Beaufort Sea. The new book, which is available from the American Association of Stratigraphic Palynology, contains an evaluation of the world literature and detailed descriptions of over 1,000 species. It will be a useful reference for new exploration in the Beaufort Sea.

Baffin Island work triggers exploration

The GSC and the Canada-Nunavut Geoscience Office successfully completed the first year of a jointly funded study of Central Baffin Island. The work responds to the Government of Nunavut's priority need for bedrock geoscience information to support land-use planning, economic development and resource assessment. Following the release of results and preliminary versions of four bedrock geology maps, three companies (BHP, Cominco and Falconbridge) advanced an estimated \$250,000 to obtain 36 exploration permits.



The field camp for the Central Baffin project was home to up to 25 geologists, geophysicists and university students from all across Canada, as well as support staff.

M. St-Onge, GSC

TARGETED GEOSCIENCE INITIATIVE



In June 2000, the Government of Canada introduced the \$15-million, three-year Targeted Geoscience Initiative (TGI) to produce new geological maps and data for under-explored areas with a high potential of mineral deposits. This initiative is led by the GSC for Natural Resources Canada.

TGI's overarching goal is to turn resource potential into new social and economic benefits by increasing the level and effectiveness of private sector mineral exploration, and thereby promoting mineral development. In particular, TGI will build a state-of-the-art geoscience infrastructure for Canada by improving the quality and quantity of geoscience information available and promoting its rapid dissemination on the Internet.

The 23 TGI projects underway across Canada include such activities as identifying rock formations with a strong potential for diamond and gold deposits, providing innovative geological models to support and stimulate mineral exploration, and putting geological data online.

The Government of Canada's contribution to these projects is also encouraging additional investment from other federal, provincial, territorial and industry sources, which are collaborating on the design and delivery of the projects. The result is almost \$40 million over three years in enhanced geoscience activities. TGI projects are also providing valuable training opportunities for a large number of university students.

TGI has triggered an exciting range of new projects. Highlights from its first year of activity include:

National Geochemical Reconnaissance (NGR) surveys

The GSC and B.C. Geological Survey carried out a standard NGR survey (stream sediment and water sampling) over 12,000 km² in north-western B.C. This is the first of three surveys targeting areas of known mineral potential in an effort to attract and focus mineral exploration activities. With the Alberta Geological Survey, the GSC carried out an orientation NGR survey in northeastern Alberta in areas known to host kimberlite pipes. Sample media (including till, tree bark, needles and twigs, soil and humus) will be tested to determine the most suitable material to be collected in a broader survey in 2002. With the New Brunswick Department of Natural Resources and Energy (NBDNRE), an NGR standard survey was conducted over 2,100 km² in the Hayesville and Coldstream areas, both identified by the N.B. government and the N.B. Prospectors and Developers Association as a high priority area for mineral exploration.

Nunavut's rich resources

The Committee Bay greenstone belt occupies the central portion of a poorly known region extending from Baker Lake to northern Baffin Island. Recent geological studies and exploration activity have highlighted the importance of gold associated with the deformed iron formation of the Meadowbank deposit to the southwest and the under-explored Committee Bay greenstone belt located in Central Nunavut. Integrated aeromagnetic surveying, bedrock and surficial mapping of a 300 km-long segment of the belt will greatly enhance mineral exploration efforts in this region.

Diamond exploration in northern Quebec

This integrated geoscience mapping project complements the Quebec Ministère des Ressources naturelles' Grand Nord initiative, aimed at promoting mineral exploration in northern Quebec. The recent surge of diamond exploration in this region emphasizes the need to reconstruct regional glacial dynamics and to identify associated dispersal patterns in glacial sediments. During the project's first year, new knowledge on glacial dynamics was gathered, and reconnaissance-scale surveys of geochemistry and diamond indicators allowed for an early assessment of the region's potential.

Abitibi region, Quebec

The Doyon-Bousquet-LaRonde mining camp, the second largest gold producer in Quebec, is the site of a multidisciplinary collaborative project involving the Quebec Ministère des Ressources naturelles, industry (Cambior, Agnico-Eagle, Barrick), the Royal Ontario Museum and universities (INRS and UQAC). Work conducted in the project's first year helped to better define key geological parameters controlling the formation, distribution and nature of the various styles of mineralization present in the district. This information is crucial to the design of geological models for gold-rich volcanic massive sulphide (VMS) deposits and to the development of new exploration tools for enhanced success in exploration.

Sudbury area

The first major GSC study of the rich nickel-copper-platinum group element deposits of the Sudbury Basin began with studies of the sulphide ore bodies and their host rocks. Suites of both sulphides and host rocks were collected for petrographic and geochemical analysis. A study of volatile elements in the Sudbury Igneous Complex and a database compilation of existing literature from a variety of sources were also begun. Partners include Laurentian University, INCO, Falconbridge and the Ontario Geological Survey.

Bridging the geology of Labrador and Quebec

This partnership project, with the Quebec and Newfoundland geological surveys and universities, will provide the first complete tectonic transect across the eastern Grenville Province. It will bridge the geology of Labrador and eastern Quebec, while expanding the geoscience data and knowledge base with new geological maps, thematic studies, geochronology and more efficient mapping tools. The goal is to renew current understanding of the geological framework of the Eastern Grenville and provide innovative, process-oriented, geological models to support and stimulate mineral exploration. Over the past year, researchers have, for the first time, recognized potentially volcanogenic units that could be prospective for minerals, but more work needs to be done to link their origin with the regional context.



GSC scientist, Léopold Nadeau, conducting field studies on the Lower North Shore, Quebec.

Exploration science and technology (EXTECH)

EXTECH is a GSC program that develops new approaches to mineral exploration in Canada and stimulates exploration in established mining camps.

- EXTECH III, in Yellowknife, is a multidisciplinary project that is developing an improved exploration model for gold deposits and addressing the important economic problem of declining metal reserves in the Yellowknife Mining Camp. TGI support permitted an early release of both 2D and 3D GIS digital data compilations and the development of a 3D model of the Giant and Con gold mines in conjunction with underground and regional geological, surficial and metallogenic studies. It enabled the continuation of a regional drift prospecting and biogeochemistry study to follow up anomalous gold grain and diamond indicator minerals in tills and to establish baseline arsenic and base-metal levels and distribution in the Yellowknife area. It also funded a continuation of a mineral deposits and structural study of the Crestaurum Mine property.
- EXTECH IV will enhance the four-dimensional knowledge base of the Athabasca Basin in northern Saskatchewan. It will develop new exploration methods for deep uranium deposits in an effort to sustain and enhance the environmentally sound development of this productive mining camp. TGI funding is supporting all aspects of the program, including multiparameter geophysical and geological studies, hydrocarbon analysis, basement, structural and stratigraphic programs, all of which will lead to improved understanding of ore-forming processes in this uranium-rich region.

Flin Flon Mining Camp

The GSC, in collaboration with the Manitoba and Saskatchewan geological surveys, Hudson Bay Mining and Smelting, and Aur Resources, undertook studies of volcanic-associated massive sulphide deposits. A study of regional hydrothermal systems as an exploration guide began with documentation of deposit and regional scale alteration. A 3D analysis of the basin, which hosts the large Callinan, Triple 7 and Main Mine deposits, commenced as did cross-border mapping between Manitoba and Saskatchewan. The project will provide a better understanding of the large-scale controls on the formation of volcanogenic massive sulphide deposits in the Flin Flon area and improve deep exploration methods in this productive mining camp.

Atlin, B.C.

This project is designed to advance understanding of the mineral resource potential and geological evolution of the northern Cache Creek Terrane. Project objectives are being achieved through the acquisition and integration of new geophysical and geological data. High-resolution aeromagnetic data acquired during the first year of this three-year project will be released October 2001. Systematic geological mapping was also undertaken to establish the stratigraphy of the terrane and focussed studies were conducted on units with significant potential to host volcanogenic massive sulphide deposits. The gold potential of selected intrusive suites is being investigated in light of recently identified anomalous stream sediment geochemistry data. The project is being jointly executed by the GSC and the B.C. Geological Survey, with the help of geoscientists from several universities.

Bella Coola, B.C.

This three-year project will map an under-explored area with high base-metal mineral potential in the volcanic rocks of the eastern Bella Coola map area. In preparation for the first field season in 2001, the 1994 B.C. Geological Survey mineral potential compilation for the area was augmented with data tables of mineral deposits and mineralized occurrences, and fossil sites. A database of existing isotopic age dates is nearly complete, and work has started to digitize some pre-1965 GSC field station data. An NGR survey of the area is planned.

Airborne surveys support exploration

Large portions of the remote Phelps Lake area of northeastern Saskatchewan are not well mapped and remain virtually unexplored for mineral potential. Lake sediment geochemical surveys carried out in the region have defined several anomalies that could indicate the presence of scattered gold, base metal, rare earth element and uranium occurrences.

Airborne gamma-ray/magnetic/VLF surveys over similar geological units and deposit types elsewhere in Canada have contributed to improved geological maps and mineral exploration models. Radioactive element patterns (potassium, uranium and thorium) can delineate exposed rare earth element-enriched units, potassium alteration associated with gold and base metal deposits and existing and undiscovered uranium occurrences. The results of this survey will be merged with new geological mapping

to improve understanding of the geological context and mineral potential in the area.

The Uranium City area hosts numerous, unstudied base metal and gold deposits, and has rare earth element, silver and molybdenum lake sediment anomalies. The region also has several past uranium producers and several dozen significant uranium occurrences. These types of deposits, their host rocks and related alteration typically manifest themselves in easily mapped airborne gamma-ray/magnetic/VLF patterns or anomalies. Similar detailed surveys conducted elsewhere in Canada have contributed to improved geological maps and mineral exploration models.

These surveys were undertaken as part of the Government of Canada's Targeted Geoscience Initiative in partnership with the Saskatchewan Departments of Energy and Mines and Northern Affairs.



GSC summer student Charlie Murphy at Bonokoski Lake groundtruthing new data collected as part of the TGI-funded airborne survey in northeastern Saskatchewan.

R. SHIVES, GSC

Slave Province, N.W.T.

The Walmsley Lake area, northeast of Yellowknife, is an area of active diamond exploration, with lesser known potential for gold and base metals. This project is designed to improve the framework for mineral exploration by generating new geological maps and understanding for a poorly documented region. Isotopic and geophysical methods are being used to map age domains and lithospheric structure in the southeastern Slave province for developing tectonic and related diamond exploration models for the Slave craton. Work in the first year provided key geological field relationships resulting in a geochronological framework.

Stewart River and Finlayson Lake area, Yukon

TGI funding enabled the Ancient Pacific Margin NATMAP Project to conduct a multi-parameter geophysical survey, in addition to the bedrock and surficial mapping originally planned for the Stewart River area. In the Finlayson Lake area, it allowed the GSC to extend the area mapped and complete a till and sediment stream geochemical survey. Some 12,800 line kilometres of multi-sensor helicopter-borne geophysical data were collected, and these will help identify targets for mineral exploration. Bedrock mapping identified a previously unrecognized coherent stratigraphy favourable for hosting base-metal, volcanogenic massive sulphide deposits. Mapping of the surficial geology focused on Pleistocene volcanism, the regional settings of gold placers, and use of stream gravel lithology to search for gold-related intrusives in areas with few bedrock exposures.

For a complete listing of TGI projects, visit:
www.nrcan.gc.ca/gsc/tgi_e.html

Ancient Pacific Margin Project delivers

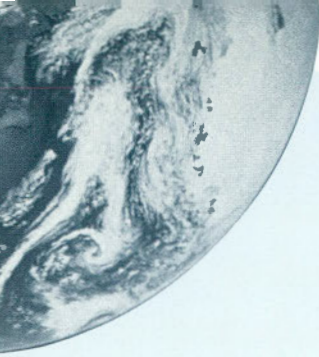
As a result of two years of consultation with potential partners and clients, this project is delivering a strong and focused geoscience program for a mineral-rich belt of rocks that stretches from Washington State to Alaska. The research team includes the GSC, Yukon Geology Program and the B.C. Geological Survey, with participation from several U.S. agencies and five universities, and support from two exploration companies. Deliverables have been impressive, with 47 publications and 26 maps released so far. In addition, 25 project participants held a productive four-day field trip to examine a poorly understood belt of rocks on the Yukon-Alaska border that hosts significant gold and base metal potential. At a review meeting, attended by 80 geoscientists, the NATMAP team received solid insight into the products (scale, format, combination of datasets) that industry needs.



Rob Stevens (r) and Bob Thompson, participants on the annual Ancient Pacific Margin NATMAP field trip, stand near the eastern limit of Yukon Tanana terrane, Swift River area, Yukon.

J. Nelson, BC Geological Survey

NATMAP: Partnerships with big benefits



NATMAP, Canada's national geoscience mapping program, is designed to increase the level and quality of geoscientific mapping of Canada.

NATMAP projects pull together teams of provincial, territorial, university, industry and GSC researchers. They have been an outstanding success in terms of scientific results, innovation, impact on Canadian industry, and the training and development of Canadian scientists. Economic benefits from these projects are significant.

NATMAP contributes to gold discovery in Nunavut

As part of its broader coverage, the Western Churchill NATMAP project has produced a comprehensive geoscience knowledge base in the region encompassing Cumberland Resources' existing Meadowbank gold deposit, north of Baker Lake. Cumberland has acknowledged the contribution of the GSC to their acquisition of an additional 30,000 Ha of prospective ground, extending 20 km beyond the known Meadowbank deposit (estimated at 2.1 million ounces of gold). Cumberland announced, based on drilling on their new holdings in 2000, that the Vault gold prospect has been upgraded to deposit status. The gold zone has been traced to 110 metres depth, and remains open for expansion in all directions from surface. The new discovery has excellent potential to enhance the economics of the Meadowbank project. Cumberland Resources is optimistic that continuing exploration will not only expand the Vault deposit but will also identify more deposits.

Oil and gas exploration impact

Mapping in the northeastern B.C. phase of the Central Foreland NATMAP project (Liard and Trutch areas) was completed in 2000, with the collaboration of the B.C., Yukon and N.W.T. geological surveys, six universities, and industry (Gulf, Crestar, Nexen, Petro-Canada, Purcell and Talisman). Documented evidence from these and other petroleum companies active in the Trutch area indicate that the GSC project has resulted in over \$500,000 of cost savings and improved exploration focus, and given rise to investment commitments of at least \$100,000,000 (exploration geophysics and drilling). The project is now focusing on the Fort Liard area of southwestern N.W.T., immediately adjacent to the world-class gas discoveries that have generated much industry interest.

Appalachian Foreland and St. Lawrence Platform Project

This collaborative project's goal is to provide new models to support hydrocarbon and mineral exploration in the ancient continental margin of eastern North America. By focusing on five regional geological transects, new advances have yielded improved stratigraphic and structural frameworks to assist government and industry exploration interests in the area. The past year also saw significant progress in mapping by the geological surveys of New Brunswick, Quebec and Newfoundland, while thematic studies have led to interprovincial correlations. The multi-partner team of over 40 scientists has contributed to knowledge generation and its diffusion through the new virtual library of the Geo-Atlas of the St. Lawrence (www.cgq-qgc.ca/gasl).

MINERALS



Mineral exploration and mining are cornerstones of the Canadian economy—essential to the international trade balance, job creation and community development. GSC's minerals research provides geoscience innovation and insight that helps the mineral exploration industry discover the reserves required to sustain Canada's position as one of the world's leading suppliers of minerals and metals. It also ensures that the Canadian government has the geoscience information necessary to formulate mineral policies in areas of federal jurisdiction and to promote the technological capability of the Canadian exploration services industry.

New "roadmap" for national mineral deposits research

Staff from the GSC, University of Alberta and TECK Corporation organized a Geological Association of Canada conference on future directions for Canadian mineral deposit and metallogenic research. The 71 participants, from all parts of the geoscience community, reached consensus on key points that will shape future research in Canada. Most important were the need to address the issue of industry sustainability and to use networking between universities, government, industry and the federal funding body NSERC as the most efficient means to deliver mineral deposits research. A CD-ROM listing Canadian mineral deposits researchers is being compiled, and a second conference will examine the feasibility of developing a national centre of excellence in sustainable mineral resource development.

New look at Timmins area

An important gravity survey, covering 28 townships in the Timmins area, was undertaken as a joint venture of the Ontario Geological Survey, Placer Dome, Explorers Alliance Corporation, Geodetic Survey and the GSC. It is expected to give mineral exploration companies a clearer window into one of the most productive gold and base metal mining camps in Canada. The survey maps, released in the spring of 2001, will increase geological knowledge, encourage mineral exploration and help maintain Ontario's position as a leading area in Canada for mineral industry investment.

New mineral exploration techniques

The Downhole Seismic Imaging (DSI) Consortium partnership with Falconbridge, Noranda and several universities has developed novel instrumentation and successfully demonstrated its capability for cost-effective mapping of ore zones and structures at depths of two to three kilometers (commensurate with depths of practical sustainable mining). The technology will aid deep exploration in existing mining camps. The project moved to the technology transfer stage this year. Vibrometrics conducted mapping projects worth over \$500,000, and Quantec Geosciences Ltd. is providing financial support for software development.

Short course for diamond industry a success

GSC staff have been receiving good feedback about the course they developed in collaboration with UBC, McGill University and De Beers for the diamond industry on "Geophysical and Geochemical Imaging of Canada's Upper Mantle". It was presented at the 1999 Yellowknife Geoscience Forum and the 2001 Prospectors and Developers Association of Canada meeting. Participants have found the course to be particularly useful in the search for new potential diamond provinces, as well as for sustained development of the Slave Province.

Mining Hall of Fame

Jim Harrison, who headed the GSC from 1956-1964, was inducted into the Canadian Mining Hall of Fame. He joins other GSC Hall of Famers: Sir William Logan, Joseph Tyrrell and Robert Boyle, as well as industry leaders Norman Keevil and William James who spent significant periods of their careers with the GSC. Visit the Mining Hall of Fame at www.halloffame.mining.ca.

Lessons from the Antarctic seafloor

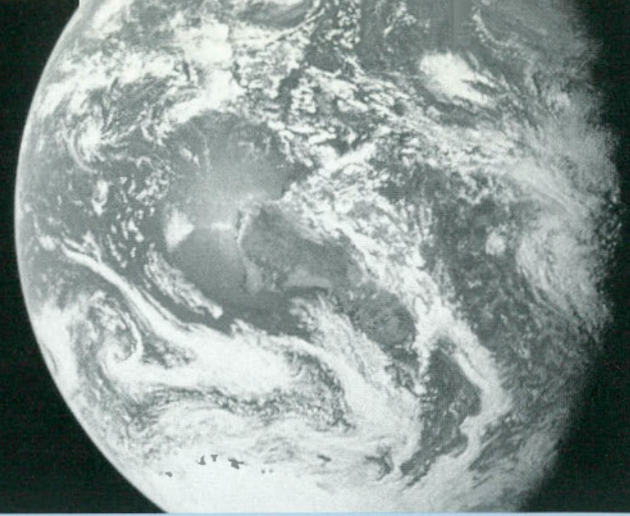
As part of a German-Canadian research project on seafloor minerals, two GSC scientists travelled to the Bransfield Strait in Antarctica. This is one of the few locations on the ocean floor where active rifting of a continental margin can be observed. The project's goal is to document new ore-forming environments in previously unexplored regions. The work has direct implications for mineral exploration in similar terranes now preserved on land. In this case, Bransfield Strait is thought to be similar to that in which many large base metal deposits, such as New Brunswick's Bathurst Mining Camp, have formed.

Using the German vessel *Sonne*, the researchers mapped and sampled the deposits and carried out detailed surveys of the adjacent sub-basins. In addition to shallow-water (<1,000 m) zinc-rich deposits, they found evidence for older hydrothermal activity at a depth of more than 2,000 m. They also investigated geothermal activity at the nearby Deception Island caldera. This volcano is the largest and most active volcano in the region, with a history of recent eruptions that destroyed a British research station on the island.



A sampling expedition from **RV Sonne** in the caldera of Deception Island

ENERGY



The energy industries represent another cornerstone of the Canadian economy. Geoscientific knowledge about the energy resources contained in Canada's sedimentary basins supports the environmentally responsible development of these resources. GSC research on regional hydrocarbon geoscience is carried out with provincial and territorial agencies and with industry. Integrated thematic studies focus on the processes by which hydrocarbon deposits are formed and the geological characteristics of known resources.

New Beaufort-Mackenzie research consortium

Following the upsurge in northern oil and gas exploration interest, which has seen recent land sales and exploration commitments of almost one billion dollars, a GSC research consortium was formed with eight oil companies (Anderson, AEC, Petro-Canada, Shell Canada, Anadarko, Burlington Resources, Chevron Resources and BP Canada Energy) to investigate the pressure, temperature and heat flow histories, detailed biostratigraphy and source rock/oil geochemistry of the Beaufort-Mackenzie region. GSC resources for the project are leveraged by significant cash contributions from industry. Existing datasets have been converted to a common format and made accessible on the Web to consortium partners, through a search engine developed by GSC. Old data continue to be converted and added to this web-enabled dataset, and new data are beginning to be generated in response to direct requests from the participating companies and where gaps in the previous knowledge base have been identified. The initial phase of the research is slated to take three years.

Potential new oil plays

Research on petroleum fluid mixing in the Devonian-Carboniferous Bakken/Madison petroleum systems of Williston Basin in Saskatchewan has pointed the way to possible new petroleum plays in the area, attracting significant interest from Canadian industry. The Bakken study has also proved its utility world-wide as a model for petroleum expulsion, secondary migration and accumulation in unconventional reservoirs.

Oil and gas resource assessments

The GSC completed resource assessments of the conventional oil and gas potential of three of Canada's frontier basins: the Yukon's Old Crow and North Coast basins, and the Jeanne d'Arc Basin, offshore Newfoundland. The Yukon basin resource predictions are important contributions to an overall resource assessment of the Mackenzie Corridor. Significant progress was made in compiling and evaluating the petroleum geology of the Colville Hills, Anderson and Horton plains, and Great Bear Plain in the Mackenzie Corridor, for a future petroleum resource assessment. Progress was also made in evaluating new geological knowledge derived from recent mapping in the B.C. interior in order to begin a reappraisal of oil and gas potential of the intermontane basins of Canada.

New light on the Athabasca sandstone

Organic petrology and geochemistry research on the Athabasca sandstone in northern Saskatchewan, carried out as part of the EXTECH IV project, has revealed that solid bitumens associated with the uranium deposits are potentially sourced from organic-rich (probably oil-prone) potential hydrocarbon source rock strata. Beyond the immediate exploration implications for the Athabasca Basin, these findings show that sufficient quantities of organic matter were preserved during this geological period to allow for real petroleum potential in other Proterozoic Canadian basins.

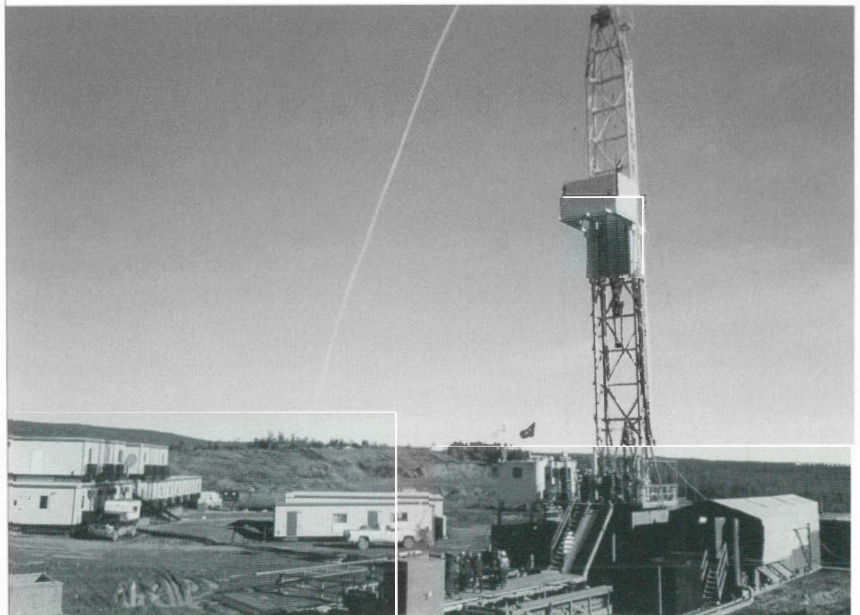
New models for Cretaceous shales

Results of a multidisciplinary study of Cretaceous shales of the Western Canada Sedimentary Basin (WCSB) were presented at GeoCanada 2000, and work is progressing on a final report. During the past year, models have been developed for quantifying petroleum source rock properties from log measurements and these have been tested using published geochemical data and newly-acquired geochemical and petrophysical data. Modeling of the deposition, compaction, fluid expulsion and pressurization history of the WCSB Cretaceous is considered to be vital input to the identification of any new (stratigraphic or geographic) frontiers still to be explored in the foreland basin province of western Canada.

New international gas hydrate program

A new gas hydrate field program will be launched in late December, with five international partners agreeing to drill a natural gas hydrate research well in the Mackenzie Delta in the winter of 2002. The GSC has been the driving force behind the project and will coordinate the scientific studies, as it did in an initial program in 1998. The new 1,200 m-deep research well will be used for advanced scientific and engineering studies aimed at determining the production potential of gas hydrates (a promising alternate energy resource), the susceptibility of gas hydrates to climate warming, and the geohazard that gas hydrates present to conventional drilling.

The field program will be engineered by the Japan Petroleum Exploration Company with partners including the GSC, Japan National Oil Corporation, GeoForschungsZentrum Potsdam (Germany), U.S. Department of Energy, U.S. Geological Survey, India National Gas Hydrate Research Program and the International Continental Drilling Program. The partners have confirmed funding at \$12.5 million, with another \$11 million in indirect support. When completed, the Mackenzie Delta Production Research Well will be the first of its kind in the world, further establishing Canadian expertise in this area.



GeoCanada 2000: A landmark meeting

The largest-ever meeting of the Canadian earth science community took place in Calgary, May 29-June 2, 2000. Billed as the "Millennium Geoscience Summit", GeoCanada 2000 attracted over 5,000 participants, drawn from the six sponsoring societies: Geological Association of Canada, Mineralogical Association of Canada, Canadian Geophysical Union, Canadian Society of Petroleum Geologists, Canadian Society of Exploration Geophysicists and Canadian Well Logging Society. GeoCanada 2000 gave Canadian earth scientists a chance to compare accomplishments, chart future directions, and build cross-disciplinary networks.

GSC staff were prominent in organizing the conference and in the technical program. In addition to chairing sessions, leading field trips and presenting short courses, GSC scientists contributed over 120 scientific talks and 80 displays.



GeoCanada 2000

Minister Goodale set the tone for GeoCanada 2000 with his opening speech about the pivotal role that geoscience plays in the social and economic well-being of the nation.

Coalbed methane: new products

The GSC released a number of benchmark products on coalbed methane in 2000: a GSC Bulletin providing detailed documentation and evaluation of coalbed methane exploration activity in Canada, a CD-ROM database (NATMETH) for industrial explorers and policy analysts, and a report estimating that there may be on the order of 187 TCF of natural gas originating as coalbed methane in the Alberta Plains alone. Additional coalbed methane research related to climate change/carbon sinks suggests that coal seams may provide ideal sites for the permanent sequestration of the greenhouse gas CO₂.

- *An assessment of coalbed methane exploration projects in Canada* by F.M. Dawson, D.L. Marchioni, T.C. Anderson and W.J. McDougall (Bulletin 549).
- *National coalbed methane database* by F.M. Dawson, W.J. McDougall, T.C. Anderson, D.E. Pearson and T.M. Molnar (Open File D3927).

Field guide for the southern Alberta foothills

The GSC produced a new geological field guide for the southern Alberta foothills from Calgary to the U.S. border. The region is one of intense industry and academic interest. Over the last year GSC staff led five field trips to the area for geologists and geophysicists from Canada, U.S., China, France, Belgium, and Italy. The southern Alberta Foothills are considered the "type" area for fold and thrust belt oil and gas provinces.

Northern Basins Initiative

The North's importance in Canada's political, economical and environmental landscape during the 21st century is evolving dramatically, and one of the key drivers of this is the quest for new energy reserves and related infrastructure development.

Studies predict that in about 15 years North Americans will consume 30% more natural gas annually, as power plants across North America are refitted or built to burn natural gas. The North's sedimentary basins, where huge volumes of gas are known to occur, will rapidly become the focus of exploration. This has already been demonstrated by close to a billion dollars worth of expenditures by industry in the Beaufort-Mackenzie Basin, as well as by the various pipelines under consideration to link the North's rich reservoirs to southern Canada and the U.S.

The GSC's Northern Basins Initiative is looking into the many facets of oil and gas exploration and development. As an important first step, northern stakeholders came together with GSC staff to assess the gaps, needs and opportunities in the northern basins, October 11-13, 2000, at GSC's office in Calgary. More than 60 representatives from the federal government and the Yukon, N.W.T. and Nunavut territorial governments met to discuss a range of northern issues including: the federal Northern Science and Technology Research Plan and the NSERC-SSHRC Task Force Report on

Northern Research; Canadian sovereignty over the Northwest Passage; climate change, environmental impacts and marine geohazards in the North; the impacts of pipeline developments on aboriginal communities; the mineral potential of northern sedimentary basins; and the industry perspective on northern oil and gas developments.

Participants also discussed how northern stakeholders (territorial and federal departments, First Nations, universities and industry) could undertake multidisciplinary research in the basins of the North and start closing the gap between the rising needs and the capacity of scientific organizations to respond to these needs.

Building directly from these discussions, the GSC and a number of territorial partners (N.W.T.'s C.S. Lord Centre, Yukon Economic Development, Canada-Nunavut Geoscience Office, Nunavut Tunngavik Incorporated) have embarked on a one-year scoping study to further examine the gaps, needs, challenges and opportunities in northern basins and to lay down, through a concerted research plan, the foundation of a renewed geoscientific effort in the North.



A. Embury, GSC

Exploration well drilled in 1979 on Cornwall Island (Nunavut) by Mobil and Panarctic.

DID YOU KNOW?

The GSC-led Geoscape project is turning local geoscience into educational posters and websites for 15 communities across Canada. Geoscape teams include local scientists, educators and municipal planners.

NATURAL HAZARDS



Earthquakes, landslides, magnetic storms, and even volcanic eruptions are all potentially damaging geological hazards in Canada. Permafrost and naturally occurring metals in the environment are also geological conditions that can pose hazards. The scientific information that the GSC provides about these hazards is the basis for sound land-use and emergency preparedness planning that touches directly on the safety, health and well being of Canadians.

Toxic Substances Research Initiative

A three-year Health Canada-funded project is entering its final year of mercury research in Kejimikujik Park, N.S. The team includes 15 researchers from federal and provincial governments and universities. The project is aimed at determining the processes and sources of mercury within the ecosystem that have led to the highest levels of mercury in loon blood to be found in North America. Research areas include the importance of wetlands to the production and transport of methyl mercury, the effects of soils and geology as a mercury source, and mercury flux from various media. New areas of research that were incorporated into the project's second year include the importance of microbiological processes in mercury cycling and transformations, sedimentation processes as a sink for mercury, and the significance of groundwater in mercury transport.

Pollution record in tree rings

The GSC's DINAMITE (Dendrochemical Investigation of Natural and Anthropogenic Metals In The Environment) has developed a powerful tool, based on information found in tree rings, to assess environmental pollution. Dendrogeochemistry has confirmed its capacity to determine the impact of smelters in the distribution of metals in tree rings, the impact of which can be detected more than 35 km from the source. Beyond that distance, the concentrations of metals in tree rings represent low-level pollution plus natural accumulations. This approach will be used in a new study to track low-level atmospheric pollution in northern Canada.

Flood hazards along the Red River

Work by the GSC and the Manitoba Geological Survey has developed another innovative use of tree rings, resulting in a flood record for Manitoba's Red River dating back to 1460. "Flood rings" (distinctive tree rings that develop during a year of high-magnitude flooding) have enabled the reconstruction of a record of large flood events for the Red River. Most of the major known floods of the 20th and 19th centuries have been successfully identified from the tree-ring record, and more important, seven previously unknown floods in the 1700s and in 1538 were identified for the first time. This new insight about past flood behaviour will be valuable for assessing flood hazard in the Red River area.

Earthquake-induced landslides near Ottawa

Recent evidence suggests that the area east of Ottawa was the site of two of the most geologically destructive earthquakes in eastern Canada. Numerous large earthflows, of sizes unequalled in historical time, occurred concurrently about 4,550 years ago in different valleys. The severity of the geological response to the shaking is due, in part, to the highly sensitive nature of the marine sediments in this region. These new discoveries provide evidence that this region, which is known as a seismically “quiet” section of the Ottawa-St. Lawrence seismic zone, may be subject to high-magnitude earthquakes.

New publication on Canada’s geological hazards

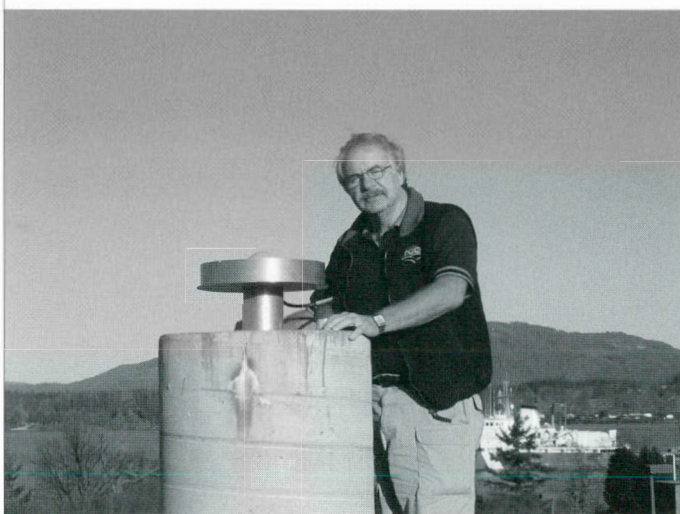
Earthquakes, volcanoes, landslides, sea-level rise, permafrost degradation are just a few of the geological hazards that shape the Canadian landscape and affect our society. The GSC studies these hazards to provide baseline information necessary for public safety, environmental protection and sustainable development. Globally, there has been a marked increase in the frequency and cost of natural disasters. Some reasons include increased population in disaster-prone areas, and growing dependence on technology vulnerable to natural hazards. Global climate change may also be affecting the frequency and magnitude of many types of hazards. The new GSC publication, *A Synthesis of Geological Hazards in Canada*, (Bulletin 548) is a fundamental reference and resource for understanding geological hazards in Canada.

Reducing geological hazards

The GSC and Geomatics Canada consulted with representatives from across Canada in support of developing a national program for reducing risks to Canadians from geological hazards such as earthquakes and landslides. Several initiatives have resulted from this consultation. In Eastern Canada, for example, the St. Lawrence valley is the most sensitive zone in Canada to mudslides. A partnership with Civil Protection Canada and the Quebec ministries of transport, public safety and municipal governments was formed to document the mudslides that occurred within the last 150 years in Quebec and southern Ontario, resulting in a database of mudslide risk in Eastern Canada.

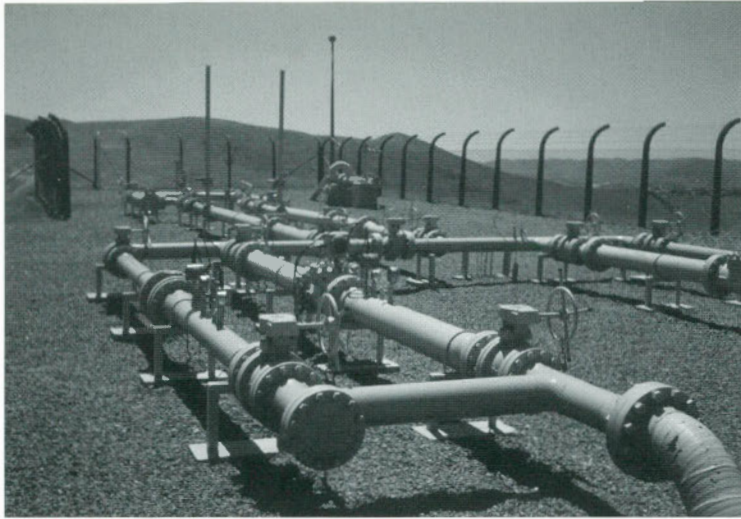
New behaviour for plate motions along the West Coast

The GSC discovery of a new aspect of West Coast subduction zone dynamics was released by the prestigious journal *SCIENCE* in an article documenting the “silent slip” behaviour of the Cascadia subduction zone. Previous research has established that the shallow part of the subduction fault is locked, accumulating energy for the next great (magnitude 8 or 9) megathrust earthquake. The most recent GSC research used continuous GPS observations from southern B.C. and northern Washington State to show that the deeper (and hotter) part of the fault, instead of slipping steadily as was formerly assumed, underwent a period of rapid slip over a few weeks in the fall of 1999. It was dubbed “silent slip”, because the rupture was not accompanied by shock waves normally produced in an earthquake. Since it is the relative motion of plates across the deeper parts of the subduction interface that “loads” or causes stress to accumulate across the shallow locked portion of the fault, this discovery shows that loading of the megathrust zone can occur in discrete pulses. It is conceivable that at some point, one of these pulses will trigger the next subduction thrust earthquake. Monitoring the occurrence of deep slip events will lead to a better understanding of subduction zone processes, as well as providing fundamental data for estimating the likelihood of imminent thrust earthquakes.



M. Schmidt, GSC

The discovery of the “silent slip” earthquake was based on continuous GPS measurements. GSC scientist Herb Dragert, who was instrumental in making the discovery, is shown with a typical GPS monument at Sidney, B.C.



D. Boreler, GSC

Natural gas pipelines.

Space weather forecasts and hazard mitigation

The GSC, Canadian Space Agency and universities are working together in the Canadian Space Environment Program. Under this initiative, the GSC's geomagnetic forecast centre provides the Canadian Space Weather Forecast Service, issuing routine operational forecast products for Canada. The GSC's Geomagnetic Hazards Program is taking the lead in attracting industrial partners to this Canada-wide endeavour, and in conducting collaborative research with these partners. Magnetic storms, the most well-known features of space weather, can disrupt or even create a complete breakdown in a number of strategic modern technologies, such as electric power systems, pipelines, satellites and navigational systems.

Advance warnings or forecasts, combined with a good understanding of the effects of magnetic disturbances on these technologies, allow for mitigation. A five-year, \$400,000 collaborative study, involving eight international pipeline companies, into the effects of geomagnetically induced currents on corrosion in pipelines has just been completed. The improved understanding of telluric currents can now be used to help design mitigation measures that will extend the life of these strategic infrastructures and reduce the environmental damage from pipeline failures—on an infrastructure worth \$100 billion, an extension of the pipeline life by 20% would translate into a savings of \$20 billion.

Ontario Power Generation

Deep sounding seismic reflection data, extending from Ottawa to Niagara Falls, was acquired under the auspices of Lithoprobe with funding from Ontario Power Generation (OPG). The data will help improve understanding of the genesis of oil and gas pools in southern Ontario, the structure and mineral potential of the Grenville Orogen, and earthquakes in an intracontinental setting.

Pipeline infrastructure hazards

The GSC is leading an internationally sponsored project that is developing models to enable oil and gas regulators and industry to assess the integrity of pipelines under terrain hazards such as slope movement, ice scour and seismic loads. One resulting model provides a correlation between rainfall and spatial distribution of slope movement, producing information on when and where to apply remedial stress relief. Another model addresses offshore pipeline response to ice scour. These models are expected to assist northern pipeline developments in the near future.

DID YOU KNOW?

The GSC is a popular source of credible scientific information for Canadian journalists. GSC staff fielded over 700 media calls this year. Hot topics were earthquakes, meteorites, and ice studies.

Collecting earthquake profiles online

In the first four months of 2001, 26 earthquakes were felt by Canadians. Five rattled population centres enough to generate huge interest from the public and journalists (GSC seismologists gave about 200 media interviews).

Each earthquake provides useful information that furthers our understanding of these events, and GSC seismologists have a range of tools that help them develop a profile of each quake. One of the most innovative is an online questionnaire that can be filled out by anyone who has felt an earthquake and has access to the Internet.

The "Did you feel it?" questionnaire gathers information that can determine the intensity of the earthquake, which varies with distance from the epicentre. This information supplies important details about the effects of earthquakes on structures found in that location, and will help shape more effective earthquake response strategies.

The questionnaire has been a great success. For example, within one hour of the February 28, 2001 earthquake south of Seattle, 150 people had filled in the online form, with that number topping 750 the next day. The information was used to quickly determine the region over which the earthquake had been felt, and to map out the intensity distribution.

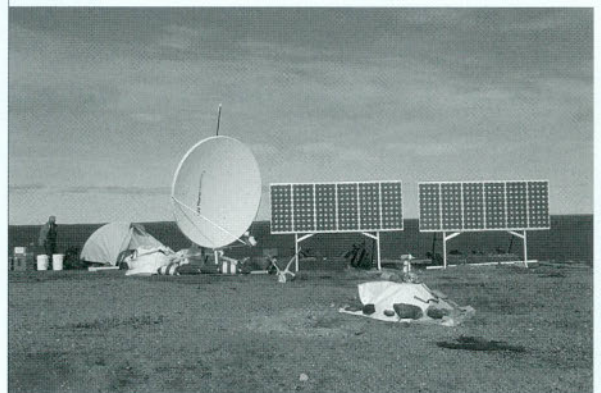
The "Did you Feel it?" questionnaires can be found at:

www.pgc.nrcan.gc.ca/seismo/intens.htm

www.seismo.nrcan.gc.ca/survey/intense_e.html

POLARIS

The GSC is a key participant in POLARIS (Portable Observatories for Lithospheric Analysis and Research Investigating Seismicity). This new \$10,000,000 program will use state-of-the-art, portable satellite-telemetry networks to study earthquake hazards in southwestern B.C. and southern Ontario. It will also provide information about Canada's important diamond region in N.W.T. Funding comes from the Canadian Foundation for Innovation, the governments of Ontario, B.C. and Manitoba, universities, Ontario Power Generation, B.C. Hydro, and diamond exploration companies.



D. Mozazedian, Carleton Univ.

A POLARIS installation at Achilles Lake, N.W.T., about 20 km northwest of the Ekati Mine camp.

Metals in foods—GSC contributes to efforts to reduce cadmium in wheat

The GSC, working with Agriculture and Agri-Food Canada (AAFC), the Canadian Grain Commission and the U.S. Department of Agriculture, is studying elevated cadmium levels in grains grown in parts of the Canadian Prairies and U.S. Great Plains.

Internationally, elevated cadmium levels in food have been linked to brittle bone (Itai Itai)

disease and increased risk of kidney dysfunction. However, those affected by Itai Itai disease exist on subsistence rice diets locally high in cadmium, and low in iron, zinc and calcium. These latter essential micronutrients are known to inhibit cadmium

retention. Rice-consuming and other populations that eat foods containing high cadmium levels, e.g., shellfish and organ meats, but whose diets are not micronutrient deficient show few adverse effects. Of concern to Canadian and American wheat producers is that internationally agreed upon acceptable cadmium levels in staple grains, based on studies of rice-consuming populations, will be used as non-tariff trade barriers against North American exports.

A GSC collaborative program studying soil and grain chemistry, which began in 1993, has shown that cadmium levels in hard red spring and durum wheats, most commonly used for bread and pasta production, are highly dependent on certain soil characteristics that control the level of cadmium uptake by wheat. Greater aridity and soil salinity in some regions, coupled with decreased soil organic carbon may lead to increased cadmium levels in wheat, as might the use of phosphate fertilisers.

In response, Canadian and American plant breeders are working to develop strains of wheat and oil seed crops that naturally accumulate less cadmium, thus limiting the impact of "contaminant" levels set internationally. The knowledge that soil chemistry is the major control on cadmium uptake by wheat has been communicated internationally by GSC scientists, working with their colleagues at AAFC, most notably to the Scientific Committee on Problems of the Environment and the Organization for Economic Cooperation and Development. In doing so, the case has been successfully presented that cadmium uptake by grains may be managed by plant variety selection, agronomy practices and selective use of the land base.

The GSC's continuing collaborative studies are helping to ensure that the various geological and biogeochemical factors influencing the cadmium content of wheat are taken into consideration in developing agronomy practices that minimize cadmium uptake.



R.Garnett, GSC

The GSC undertakes studies of soil and grain chemistry in collaboration with the Canadian Grain Commission, Agriculture and Agri-Food Canada and the U.S. Department of Agriculture. Shown here sampling durum wheat and the soil it grows in near North Battleford, Saskatchewan.

CLIMATE CHANGE



Geoscience knowledge has become increasingly important for the fundamental understanding of climate change. The GSC contributes to the Government of Canada's priorities by studying past climate changes, examining the potential for geological storage of carbon dioxide, contributing relevant data on current climate trends, and researching the impacts of climate change and possible adaptive response. Mitigation and adaptation are complementary approaches to addressing the challenge of climate change.

Adapting to climate change impacts

The impacts of changes in our climate are already evident in some regions of Canada, particularly the North and coastal areas, and these are expected to increase in the coming decades. Reducing emissions alone will not fully address climate change impact in Canada. It will also be necessary for Canadians to adapt to changing climate. The GSC is home to the Impacts and Adaptation Liaison Office, established in 1998, to administer the Impacts and Adaptation component of the Government of Canada's Climate Change Action Fund (CCAF). The office supports the development of a knowledge base that will support informed decision-making. Built on a mix of research, consultation and case studies, this information will help to identify and implement appropriate response strategies to reduce negative impacts of climate change.

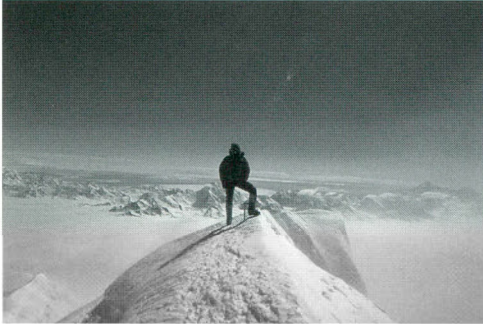
(<http://adaptation.nrcan.gc.ca>)

C-CIARN

The Canadian Climate Impacts and Adaptation Research Network (C-CIARN) was established to help identify the potential impacts of climate change in Canada and to understand the processes by which adaptation occurs. With funding from the CCAF, a series of organizational workshops was held across Canada in 2000. The Network will consist of a national coordinator, six regional nodes and seven sectoral nodes, one of which will be the C-CIARN Landscape Hazards Node hosted by the GSC. C-CIARN is a coordinating body, that encourages and stimulates climate change impacts and adaptation research in universities, government agencies, and other organizations. C-CIARN will also

ICE2001

The GSC is leading a major international project, Ice-Core Expedition 2001 (ICE2001), on Mount Logan in southern



Yukon. Its main goal is to drill a 225 metre-long ice core that will allow reconstruction of climate and environmental changes over the past 10,000 years.

Subsequent analysis of the core will provide important new insight into the relationships between the north Pacific Ocean and the climate of western North America. It will also assist in understanding climatic differences across northern Canada. This past year involved extensive planning and

staging of supplies and instrumentation on the mountain. The team left for Mount Logan in May 2001, with the drilling planned for June at a site 5,320 m above sea level. The drill team will take about three weeks to ascend the mountain to adapt gradually to the extreme high altitude conditions. Progress of the field work and subsequent analysis can be followed through the project website at www.ice2001.com.

help identify research needs and priorities. By serving as a focal point for information and facilitating interaction between researchers and stakeholders, C-CIARN will help raise awareness of climate change impacts and adaptation issues among Canadians. (<http://C-CIARN.ca>)

Permafrost degradation in northern communities

Permafrost degradation due to climate warming will affect the stability of infrastructure (e.g. roads, buildings) which relies upon the strength of the underlying frozen ground. The GSC, with support from the CCAF, started a pilot project in N.W.T. to assess impacts of permafrost degradation in Norman Wells and Tuktoyaktuk. Databases of surficial materials, permafrost conditions, geotechnical parameters, foundation systems in permafrost, and problems associated with existing buildings were compiled. These, along with modeling of ground conditions under warming scenarios, allow scientists and the communities to assess the potential impacts upon local ground conditions and the resulting effects on building foundations. Community meetings were held to discuss the potential impacts of climate change and to develop adaptation strategies and options. The databases have been given to the communities and the N.W.T. government for land-use applications as well as climate change studies.

New climate change reports

The GSC has released new reports on climate change in Canada. *Environmental response to climate change in the Canadian High Arctic* (Bulletin 529) and *The physical environment of the Mackenzie Valley, N.W.T.: a baseline for the assessment of environmental change* (Bulletin 547) are multidisciplinary reports that address past and present environments, geomorphic processes, and climate change. Both provide a context to allow reasonable assessments and predictions of future climate change in these sensitive regions. The third bulletin *The impact of climate change on rivers and river processes in Canada* (Bulletin 555) examines the relationship between climate and fluvial processes in Canada.

MARINE GEOSCIENCE



GSC's marine activities address the scientific problems and needs for geoscience information about Canada's vast coastal and offshore territories. The resulting marine geoscience knowledge supports government strategies at all jurisdictional levels, helps resolve questions related to the use of the seafloor, and is used by oil and gas, telecommunication, engineering and survey firms for a broad spectrum of exploration and development applications.

Georgia Basin marine mapping

A multibeam swath bathymetric survey of southern Strait of Georgia, B.C., was conducted as part of the new Georgia Basin Geohazard Initiative project. Preliminary results, which provide new information on earthquake-linked faults, potential slope instability and zones of seabed erosion. This information is vital for planning submarine pipeline and power-line corridors, as well as coastal and nearshore infrastructure (e.g. port facilities). A plan to extend this mapping into the transborder region between the Straits of Georgia and Juan de Fuca is being developed by a broad group of stakeholders. They are also working towards a common data standard to ensure that results can be shared between agencies and made accessible online to the public.

New aerial video of Atlantic coastline

The GSC has, over the past 15 years, videotaped the coastlines of most of Atlantic Canada and parts of the Arctic. The footage has diverse applications ranging from mapping to tourism, but one of the most important is the monitoring of changes to the landscape. An important addition to the collection was made this year with the completion of a detailed video survey along the Nova Scotian shore of the Northumberland Strait. Funding partners included the Pictou Harbour Environmental Protection Project and the Environment Canada Atlantic Coastal Action Program. The footage shows the back-shore, intertidal and nearshore areas, with a commentary describing the physical shore features, sediment character and land-use activities. Information about GSC's aerial videos is available from David Frobel at (902) 426-6867.

GSC access to industry data: a win-win situation

Data is the raw resource of science, but acquiring it is usually expensive and time consuming. This is especially true for the offshore regions. A new spirit of data sharing is growing, and the petroleum industry is leading in this trend. The GSC was given access to two important datasets for the East Coast this year.

- Industry gave the GSC a digital copy of 40,000 km of seismic data for offshore Eastern Canada. These data, acquired by the companies at a cost of tens of millions of dollars, provides important regional coverage of the Scotian Shelf and Grand Banks of Newfoundland. The data will enhance the GSC's ability to analyze the oil and gas potential of inadequately known sub-basins and deep-water areas adjacent to Sable and Hibernia, regions currently being developed.
- Nova Scotia's deep-water continental slope is a rapidly emerging frontier for hydrocarbon exploration, and oil and gas companies have acquired exploration licences in exchange for work commitments of more than \$1 billion during the next five years. The GSC and a seismic acquisition company signed an agreement that gives GSC researchers inhouse access to 35,000 km of confidential, multichannel reflection seismic data acquired by the company during 1998 and 1999. The data, worth roughly \$20 million, span water depths of 200 to 4,000 m, from south of Georges Bank to the French Corridor in the Laurentian Channel. Access to this data will fill gaps in current knowledge of the area, and contribute to GSC's assessment of regional hazards in support of safe development of the region.

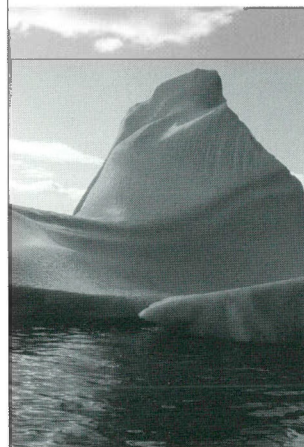
Atlantic Canada Petroleum Institute

The GSC has been heavily involved with the new Atlantic Canada Petroleum Institute (ACPI). ACPI is leading efforts to develop an internationally competitive petroleum sector in Atlantic Canada. This multi-partner organization promotes strategic, collaborative oil and gas research, identifies education and training needs, and acts as a forum for information exchange and networking. The GSC, as the largest oil and gas geoscience research presence in Atlantic Canada, works with ACPI and the Atlantic universities to ensure the development of complementary research programs. GSC staff are members of the ACPI committees that evaluate research proposals. (www.acpi.ca)

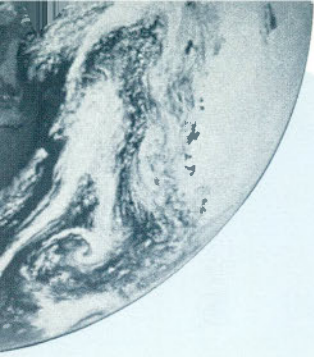
Hazards posed by icebergs

Large icebergs can plow into or "scour" the seafloor with their keels, and Grand Bank regulators and oil industry engineers are keenly aware of the risk this poses to ocean bottom facilities and pipelines. The GSC has been mapping and measuring seabed iceberg scours on Grand Bank since the 1980s, resulting in a large regional GIS database that industry uses to assess scour risk linked to the design of new structures. Appropriate regulations and cost-effective design in areas of potential iceberg scour demand detailed knowledge of the range and frequency of expected scours. GSC analyses of surveys have provided key insights into the critical issue of determining the frequency of scour on Grand Bank. There remains a need to determine the age of the scours for a given seabed location to provide a better estimate of the long-term scour frequency. GSC and industry have initiated a program to survey scours and provide essential baseline data on scour age and frequency. Understanding the low frequency of scouring events may promote new developments,

for example, by improving the economic feasibility of pipelines.



GSC



Case Study

GSC and environmental assessments

The GSC continues to play a major role in NRCan's statutory obligations in the environmental assessment of major industrial and development projects subject to the Canadian Environmental Assessment Act (CEAA). This geoscience expertise is necessary to ensure that proponents have an adequate knowledge and understanding of the physical environment, have made an adequate assessment of the effects of the environment on the project and of the effects of the project on the environment, and have identified appropriate design or mitigative measures to minimize adverse environmental impacts.

GSC expertise is required at all stages of the process, from project screening to technical review of submissions. GSC experts also take part in technical working groups and public sessions, and appear as expert witnesses at CEA Panel hearings. The most frequently required areas of geoscience expertise include hydrogeology and hydrogeochemistry, seismic hazards, surficial geology, terrain stability, and coastal, marine, fluvial and geomorphic processes.

Over the past year, GSC scientists contributed to the review of 44 projects, including marine infrastructure, offshore hydrocarbon resource development, reopening of nuclear power generation stations, decommissioning of uranium mines, and new mines, roads and hydroelectric development. Major projects were the return to service of the Pickering nuclear plant, the White Rose Oilfield Development, and the expansion of the BHP Diamond Mine.

Doing business with the GSC

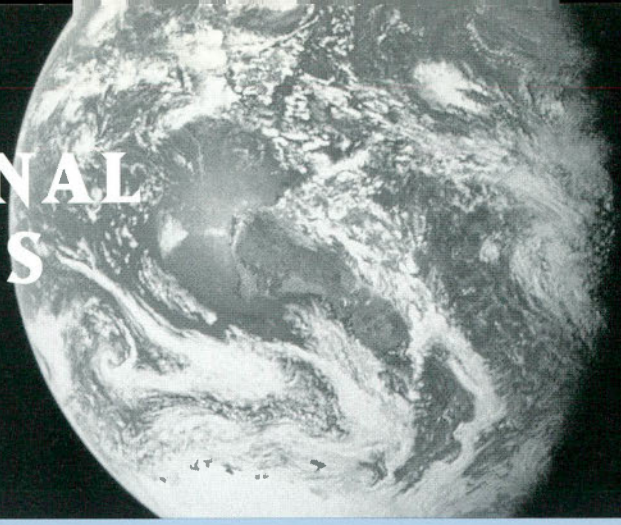
GSC makes its expertise available to the Canadian geoscience community on a collaborative and cost-recovery basis. In the case of collaborative projects, GSC works closely with industry partners, sharing costs and expertise on projects of mutual interest. Collaboration can take various forms, for example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

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

For more information on business opportunities with GSC, contact:

Business Development
Earth Sciences Sector
Natural Resources Canada
615 Booth Street
Ottawa, Ontario K1A 0E9
Telephone: (613) 996-7643
Fax: (613) 995-8737
E-mail: business.ess@nrcan.gc.ca
Website:
www.nrcan.gc.ca/ess/business

INTERNATIONAL CONNECTIONS



Canada is a recognized leader in the geosciences, and this expertise is much in demand. GSC's international connections bring significant benefits to both Canada and the partner countries. Work with other countries to carry out geoscientific research of mutual benefit has led to advances in understanding the global environment and opened doors for Canadian industry. It also exposes Canada's geoscientists to geological phenomena that may have important relevance for Canada in mineral and petroleum exploration and development, natural hazard assessment, and environmental studies.

Canada-Brazil groundwater project

The GSC is providing technical expertise to a new project that is helping northeastern Brazil cope with periodic devastating droughts through new groundwater detection and management technologies. Project funding of about \$8,000,000 comes from the Canadian International Development Agency (CIDA) and several Brazilian agencies. In its first year, ground and airborne electromagnetic geophysics, combined with Canadian Radarsat technology, were used to detect features that could be used to delineate untapped groundwater resources. Water resource development is further hindered by the lack of an electrical supply infrastructure,

and the project is promoting the use of electricity generated by solar panels to pump and purify water. Pumping and distribution stations utilize state-of-the-art Canadian solar technology that will give this region reliable and affordable power. The project also includes a significant social component that addresses community concerns and provides training on water conservation, groundwater protection and equipment maintenance.

Multinational Andean Project

The Multinational Andean Project (MAP), managed by the GSC, is a cooperative project funded by CIDA and the national geoscience agencies of Argentina, Chile, Bolivia, Peru and Canada. Its purpose is to assist economic and social development along the borders of the South American participants, mainly through mine and infrastructure development. MAP, now in its final year, has developed an impressive array of products, including a suite of litho-geochemical standards using South American rocks, a metallogenic map covering the border areas of the participant countries, a sample database with all the locations, analyses and age work completed on samples collected throughout the life of the project, and three major aeromagnetic surveys. MAP's other legacies will be the strong networks it established between all the partners and the opportunities it has provided to Canadian companies to gain a foothold in South America—for example, SIAL Geosciences of Montréal won five contracts because of its initial contracts for MAP surveys. As well, a significant South American geoscience collection has been built up in the GSC's library in Vancouver.

Asian mineral potential

GSC staff took part in a World Bank-sponsored workshop to assess the mineral potential of eight countries in central and southeast Asia (China, Mongolia, Vietnam, Laos, Kazakhstan, Kyrgyzstan, Uzbekistan and Tajikistan). The workshop brought together 15 experts from around the globe to highlight areas in these countries that may be prospective for world-class deposits of copper, gold, nickel, platinum group elements and zinc. Digital databases of the GSC's World Minerals Geoscience Database Project were of particular value to the proceedings. This industry-supported project is updating and expanding databases for a range of deposits and adding greater depth to the world geology base (for more information about the database, see page 32).

GSC contributes to international standards

Canada both conforms and contributes to international scientific standards. One such activity is the standard definition of the various geological time periods and the designation of a section locality to serve as the global standard for each. A Canadian locality was recently chosen as the base standard for the Ordovician System by an international group of scientists. They based their decision on examination of candidate sections in Australia, Canada, China, Kazakhstan, Norway, U.K. and U.S. The location is Green Point in western Newfoundland, and the base of the Ordovician time system is defined by the appearance in the geological record of a particular microscopic fossil, the conodont *Iapetognathus fluctivagus*. A ceremony to unveil a commemorative plaque and interpretive sign was held at Green Point in June 2001.

International Deposit Modeling Program

The GSC provides technical expertise and logistics support to the International Union of Geological Sciences (IUGS)–UNESCO Deposit Modeling Program, whose goal is to advance geoscientific knowledge and expertise in mineral deposit modeling for use in exploration, assessment and development of resources. Transfer of this knowledge and expertise to developing countries is a key focus. The program has staged workshops in most developing regions and symposia in conjunction with other major scientific meetings.

El Salvador earthquake and landslides

A magnitude 7.6 earthquake occurred off the coast of El Salvador, some 105 km from the city of San Salvador on January 13, 2001. A Canadian team, including two GSC scientists, travelled to the stricken country to document and investigate the landslides caused by the earthquake, as well as the damage directly related to shaking. The earthquake triggered over a 1,000 landslides, which were responsible for most of the 900 deaths. In particular, the team examined the deadly flowslide at Las Colinas that killed 585 people. Many buildings suffered non-structural damage directly related to shaking, and those that completely collapsed were almost exclusively of non-earthquake resistant construction. The Canadian team assisted Salvadoran officials in the disaster recovery and learned important lessons regarding hazard mitigation and response to similar events in Canada.



S. Evans, GSC

The landslide at Las Colinas, in El Salvador's capital, San Salvador, took place immediately following the earthquake. It buried over 300 homes, with the loss of life estimated at 585 people. This highly destructive landslide was comparatively small but exhibited an anomalously high run-out.

Digital Geotoolbox

The GSC is focussing much effort and resources to putting its geoscience online. Innovative tools, products and services, as well as important databases, are available.

A sampling follows:

Canada's Online Geoscience Data Catalogue

This important, multi-partner initiative is a priority of the Canadian Geoscience Knowledge Network (CGKN) and has received funding from the Targeted Geoscience Initiative. Its goals are to create comprehensive catalogues describing geoscience data, publications and maps that are available from Canadian geoscience agencies and to implement a new CGKN Internet search engine (<http://CGKN.net>). The project will expand upon the successful Canadian Geoscience Publications Directory, (<http://cgpd.CGKN.net>), which provides a single-point access to close to 90,000 Canadian geoscience publications produced by the federal, provincial and territorial geoscience agencies. The Online Geoscience Data Catalogue will become operational in early 2002.

GeoChemistry Online

Geochemistry Online is a "one stop" Internet-access initiative of the National Geological Surveys Committee (NGSC). Through the support of the CGKN this project has developed a solid infrastructure to ensure information quality and accessibility. Currently, the website features "real time" data from the Saskatchewan, Manitoba and Nova Scotia geoscience agencies and from the GSC. More is in the works, with other provincial and territorial agencies intending to contribute. This is a unique research tool that permits users to query a single

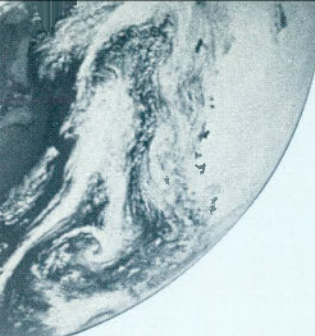
data source for their geochemistry needs, confident in the quality and consistency of information. <http://geochemia.cgkn.net>

World Minerals Geoscience Database

This industry-supported project is updating and expanding databases for gold, porphyry, nickel, sedimentary exhalative, volcanogenic massive sulphide, and other deposits into a uniform structure and adding greater depth to the world geology base. The final result will be a dynamically maintained, comprehensive and extendable database for information relating to mineral deposits world-wide. The datasets are designed to be easily used with GIS and other database software that will help in understanding the complex relationship between global tectonics and the regional settings of mineral deposits. The data may also be combined with geospatial data from other disciplines such as forestry, agriculture, topography, hydrology, biodiversity and culture to support diverse regional analyses for resource assessment, land-use strategy, sustainable development and environmental protection. www.nrcan.gc.ca/gsc/mrd/wmgdb

New nickel, copper and PGE databases

Platinum Group Elements (PGE) are the metals of the 21st century. They are essential for manufacturing the new generation of electronic devices, as well as fuel cells and catalytic converters, which will be used increasingly to generate electricity and protect the environment. These industrial precious metals are also used at some point in the manufacturing of 40% of all consumer goods. To help make Canada a more competitive exploration environment and PGE-producing country, the GSC is developing digital GIS maps and databases of nickel, copper and PGE mineral occurrences and mafic-ultramafic



bodies for each of the provinces and territories. Each database contains approximately 60 fields of information with linked graphics illustrating aspects of geology and/or mineralization, as well as pop-up windows with multi-parameter geophysical and regional geochemical data. Work is underway for the Manitoba, Saskatchewan and B.C. databases, with a completion date of two years for the entire national database.

Web-access to natural hazards data

GSC's seismic and geomagnetic data can be accessed through its website. Online data request forms can be filled out by clients and the requested information is sent by email. Online since 1994, in the past year, this service has had close to 250,000 requests for seismic waveform data, geomagnetic forecasts and data, and site-specific declination calculations. This represents an increase of 70% over the previous year. The Internet and the Web have enabled the GSC to deliver this huge volume of data to clients.

National Earthquake Hazards website:
www.seismo.nrcan.gc.ca

Canadian National Geomagnetism website:
www.geolab.nrcan.gc.ca

Current Research

GSC's Current Research series is now available online. Comprising articles describing the latest work being done by GSC scientists, Current Research 2000 is available as a CD-ROM, and includes a special release on "Radiogenic Age and Isotopic Studies". Copies of the articles may be viewed at the GSC bookstore website:
www.nrcan.gc.ca/gsc/bookstore.

ResSources GSC: Mission accomplished

The three-year ResSources GSC program was completed successfully. ResSources GSC was initiated in 1998 to better integrate GSC Internet activities and to contribute to a larger national initiative, the Canadian Geoscience Knowledge Network (CGKN), <http://CGKN.net>. Its goals were to develop methodology for placing GSC geoscience data online as well as a team with the required expertise to proceed with the task.

ResSources GSC was instrumental in fostering the development, by GSC scientists and computer specialists, of dynamic tools and procedures for managing and web-enabling GSC knowledge. During its three years of operation, ResSources supported development of 14 websites, (<http://rgsc.nrcan.gc.ca>), through an annual project approval system. ResSources GSC leaves an important legacy. It significantly increased the amount of GSC digital data available online, it fostered new connections and synergies among GSC staff across the country, and laid the groundwork for the move towards formal data management at the GSC and its participation in the CGKN.

Geology for Geophytes

With the geological record as their source book, who better than geologists to vividly bring alive the drama and majesty of the Earth's story? GSC staff have a long tradition of turning their knowledge of the Earth's secrets and their enthusiasm for their subject into accessible and understandable information to inspire and inform the broader public. The following new materials that GSC staff have helped develop will be of interest to educators, students and the public:

Geoscape: the little project that grew

The Geoscape series, pioneered by the GSC, has evolved from a pilot project in GSC's Vancouver office to a national initiative that is pulling together dynamic teams of educators and scientists across the country. These teams are producing colourful posters and websites designed to connect Canadians with authoritative information about geoscience issues in their communities. Four Geoscape projects have been completed: for Vancouver, Fort Fraser, Victoria and Quebec City, and another 11 are in the works. As well as producing much-needed educational materials about the earth sciences, the Geoscape teams result in potent, long-term links between the geoscience community and local educators, school boards, and municipal planners. The launch of a completed Geoscape project in its community becomes an opportunity for public events and has attracted media coverage.



C.Hinds, NRCCan

Panning for gold is a popular activity at the Science Funfest held every October in Ottawa as part of the National Science and Technology Week celebration.

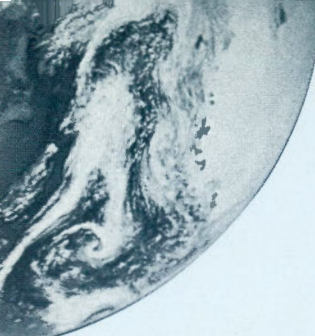
Climate change across Canada

Following the success of the Temperature Rising poster for southwestern B.C., the GSC has produced a series of posters on climate change for major regions of Canada: Prairie Provinces, Ontario, Quebec, Atlantic Provinces, Nunavut, and N.W.T. and Yukon. Each poster addresses the science of climate change and the unique impacts anticipated in that region. They are ideally suited for use in high schools as a teaching tool or as a student resource. The posters were developed by teams including federal, provincial, and territorial agencies, and a range of interest groups. Each poster will have a website and a teachers guide with regional curriculum links and a lesson plan.

<http://adaptation.nrcan.gc.ca/posters/>

New earthquake poster

A new GSC poster will help residents of Quebec's Charlevoix-Kamouraska region better understand the earthquake potential of their region and the importance of being prepared to face such an event. The geological causes of the region's earthquakes are explained in a series of questions and answers. In addition, the seismic hazards are illustrated by photographs of damage caused by the 1925 magnitude 6.5 earthquake and by a three-dimensional image that shows some 2,500 earthquakes recorded locally since 1978.



Online tour of Canada's geoscience

A photographic trip through Canada's exciting past of geoscience exploration is now just a mouse click away. Launched in June 2000, the website "Discovering Canada's Geoscience Heritage" features more than 2,000 historic photos of the geology, mineral resources and early exploration of Canada from the GSC's collection. These rare and unique images on negatives and fragile glass plates are maintained by the Earth Sciences Information Centre. The website is part of Industry Canada's Schoolnet and Digital Collections Site, which was the winner of a recent Stockholm Challenge Award. <http://collections.ic.gc.ca/geoscience>

"Rocks and Stardust" exhibit

"Rocks and Stardust", a photographic exhibit at the Canadian Museum of Nature in Ottawa, ran from December 2000 to February 2001. Curated by Peter Geldart (a great-great nephew of GSC's third director, George Dawson), the exhibit had a substantial GSC contribution including 25 photographs and scientific input by GSC scientist Rob Rainbird; mineral specimens, including samples of the world's oldest rocks from NWT's Acasta River area; and Canada's largest meteorite (the Madoc), acquired by the GSC in 1855.

Contributing to the literature

GSC scientists also contributed their knowledge, ideas and enthusiasm to new popular accounts of Canada's geology.

- "The Last Billion Years: A Geological History of the Maritime Provinces of Canada" was produced by a team of over 50 geologists, photographers and artists. Its text is lavishly illustrated with original watercolours of scenes from the Earth's past and over 150 colour photographs and diagrams. Jointly published by the Atlantic Geoscience Society and Nimbus Publishing Ltd, it is available through bookstores and museums in the Maritimes.
- "The Grasslands National Park Field Guide": GSC staff contributed a chapter on geology, paleontology and geomorphology for this Saskatchewan park. One of the treasures of the park, is an internationally renowned rock and fossil record of the famous extinctions associated with a meteorite impact in the Yucatan Peninsula, Mexico. The field guide is available through the Friends of Grasslands Inc., Val Marie, Saskatchewan.



GSC

PRODUCTS AND SERVICES



Earth Sciences Information Centre (ESIC)

ESIC holds Canada's largest collection of books, journals, maps, atlases and photographs in the earth sciences, with world-wide coverage. The collection includes an increasing number of online electronic publications.

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

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

Enquiries can be sent via the ESIC website, e-mailed to ESIC@NRCan.gc.ca, faxed to (613) 943-8742, or contact the Information Desk at (613) 996-3919. Document delivery requests should be sent to ESIC.ILL@NRCan.gc.ca. Some fees for document delivery and reference services may apply.

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

Coordinates for GSC's regional libraries are:

Calgary

Telephone: (403) 292-7165;

E-mail: calgary.ref@gsc.nrcan.gc.ca

Quebec

Telephone: (418) 654-2677;

E-mail: dupuis@gsc.nrcan.gc.ca

Vancouver

Telephone: (604) 666-3812;

E-mail: libvan@gsc.nrcan.gc.ca

Data collections for Canada's offshore

The GSC's office at the Bedford Institute of Oceanography in Dartmouth, Nova Scotia, is the principal repository for huge data collections for Canada's East Coast and Arctic offshore regions. The collections include marine acoustic, magnetic and gravity survey data; sediment grab and core samples; and rock and paleontological specimens collected as part of government/industry collaboration.

For an appointment or more information, contact:

Iris Hardy

Telephone: (902) 426-6127;

E-mail: ihardy@nrcan.gc.ca

Aeromagnetic and gravity data

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

Geophysical Data Centre
Geological Survey of Canada

615 Booth Street, Rm. 235

Ottawa, Ontario K1A 0E9

Telephone: (613) 995-5326

Fax: (613) 952-8987

E-mail: infogdc@agg.nrcan.gc.ca

Web:

http://gdcinfo.agg.nrcan.gc.ca/cat/index_e.html

Crustal-scale expertise

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

Seismics: 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. For exploration to 2 km depth, the GSC has an eight level downhole seismic tool, 2 km cable, winch and a complete processing software package www.cg.nrcan.gc.ca/dsisoft.

Electromagnetics: GSC has two high-frequency broadband magnetotelluric systems (for shallow exploration of conductors to 2 km depth or more) and 16 long-period magnetotelluric recording units (LIMS), for deeper exploration of the lithosphere, as well as display and processing software and data acquisition, processing, modeling and interpretation expertise.

Seismology and Electromagnetism
Geological Survey of Canada
615 Booth Street, 2nd Floor
Ottawa, Ontario K1A 0E9
Telephone: (613) 992-0758
Fax: (613) 992-8836

Core and Sample Repository

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

A.J. Scott
Geological Survey of Canada
3303-33 St. N.W.
Calgary, Alberta T2L 2A7
Telephone: (403) 292-7057
Fax: (403) 292-5377
E-mail: ascott@nrcan.gc.ca

Marine equipment rental

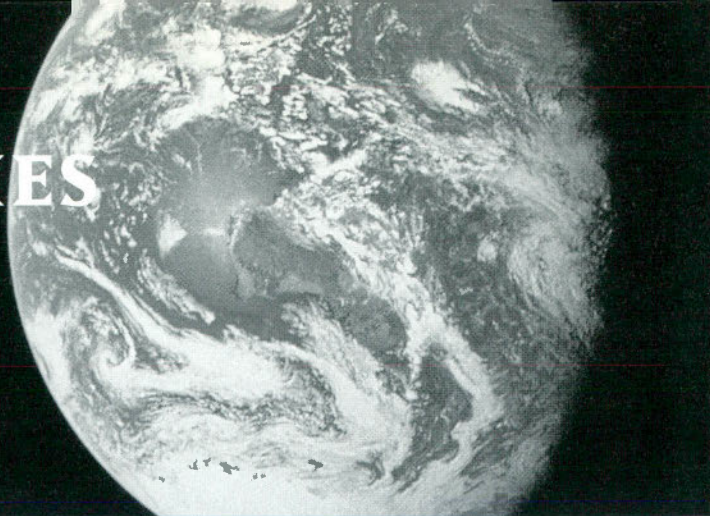
The GSC has unique marine equipment which is available for use by external partners under certain arrangements. International requests for scientific collaboration often involve the use of this specialized equipment. The GSC can make the equipment available, under agreement, to industry to enable them to tender on a contract or to be a sub-contractor on a GSC-initiated project. For example, the GSC made its ocean bottom seismometers available to a Canadian company to enable it to bid on a contract with the British Antarctic Survey to conduct surveys in the South Atlantic.

To explore possibilities, contact:

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

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

LABORATORIES



The GSC has a diverse range of laboratories that are unique in Canada. The GSC would welcome opportunities to discuss possible collaboration on the use of these laboratories.

Analytical chemistry laboratories

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

D.C. Grégoire
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8
Telephone: (613) 995-4213
E-mail: gregoire@nrcan.gc.ca

Analytical method development laboratory

This laboratory focusses on speciation of elements in sediments, soils and waters; cost-effective methods to analyse surface waters to ppb, ppt and ppq levels by ICP-MS and ICP-AES; and methods by which to differentiate geogenic and anthropogenic sources of metals. This state-of-the-art laboratory includes a Class-100 Cleanroom. New methods are designed and tested mainly through collaborative projects in environmental and exploration geochemistry with scientists in 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.

G.E.M. Hall
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8
Telephone: (613) 992-6425
E-mail: ghall@nrcan.gc.ca

Delta-Lab

The GSC-Quebec isotopic geochemistry laboratory analyses stable isotopes of hydrogen, carbon, nitrogen, oxygen and sulphur using PRISM-III or DELTA PLUS XL, in continuous flow with a Gas Chromatographer-Combustion system (GC-C-IRMS), an Elemental Analyser (EA-CF-IRMS), a Gas Chromatographer-Pyrolysis system (GC-TC-IRMS), a Pyrolysis-Elemental Analyser system (TC-EA-IRMS) and a GAS-Bench for water equilibration and carbonate digestion. With this equipment, the laboratory can cover the entire range of stable isotopic tracers applied to hydrogeological, environmental, metallogenic, diagenetic and sedimentological studies by analysing the isotopes of minerals, waters and gases.

M.M. Savard
Québec Geoscience Centre/GSC-Québec
880, Chemin Sainte-Foy, C.P. 7500
Sainte-Foy (Quebec) G1V 4C7
Telephone: (418) 654-2634
E-mail: msavard@nrcan.gc.ca

Dendrochronology and dendrogeochemistry laboratory

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

C. Bégin
Québec Geoscience Centre/GSC-Québec
880, Chemin Sainte-Foy, C.P. 7500
Sainte-Foy (Quebec) G1V 4C7
Telephone: (418) 654-2648
E-mail: cbegin@nrcan.gc.ca

Gamma-ray spectrometry laboratory

This laboratory analyses geological and environmental samples to measure absolute radioelement concentrations of potassium (%), equivalent uranium (ppm), and equivalent thorium (ppm). The spectrometer utilises two, lead-shielded, 14 cm by 14 cm sodium iodide detectors. A GSC-designed software package processes data acquired by the detectors and records gamma-ray spectra from successive samples. Calibration of the spectrometer is accomplished using potassium (RGK-1), equivalent uranium (RGU-1), and equivalent thorium (RGTh-1) standards recognised by the International Atomic Energy Agency. Laboratory services are available on a cost recovery basis.

P.B. Holman
Geological Survey of Canada
601 Booth St.
Ottawa, Ontario K1A 0E8
Telephone: (613) 992-1237
E-mail: pholman@nrcan.gc.ca

GSC labs part of major international studies

- **Climate change:** The GSC Geochronology Laboratory was asked to participate in a major research program on past climate change funded by the U.S. National Science Foundation. The selection of the lab is a testament to the GSC's world-class expertise in uranium-lead geochronology, and to the advanced technology available on the SHRIMP ion microprobe. The funding of this program for earth and environmental sciences highlights the internationally recognized need to understand the links between geological events and climate change.
- **Oldest zircons on earth:** The GSC ion microprobe (SHRIMP) laboratory participated in a project examining the oldest known terrestrial materials—4.0 to 4.3 billion year-old zircons from the Jack Hills conglomerate in Australia. Scientists from Canada, Australia, Switzerland and France are attempting to decipher the isotopic and chemical signatures within these priceless archives of geological information that have survived from the very birth of our planet. The GSC lab contributed research expertise and access to the special microanalytical capabilities of the SHRIMP for measuring U-Pb ages and trace element abundances.



The SHRIMP ion microprobe facility in Ottawa.

GSC

Geochronology laboratory

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

O. van Breemen
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8
Telephone: (613) 995-0810
E-mail: ovanbree@nrcan.gc.ca
Web: gsc-cgd.nrcan.gc.ca/cgd/geochron

Geocryology research laboratory

In 1996 the GSC and Carleton University established this laboratory at the university to facilitate joint research and to create training opportunities for students engaged in permafrost research. The GSC has contributed sophisticated thermal calibration and measurement systems to the facility, as well as technical expertise supporting experimental work and field studies. This comprehensive research-oriented laboratory supports fundamental and applied research in geocryology, exemplified by an ongoing international Arctic gas hydrate research project with participants from Canada, Japan, the USA, Germany and India. The facility also offers commercial services on a cost recovery basis.

F. Wright
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8
Telephone: (613) 996-9324
E-mail: fwright@nrcan.gc.ca

Geomagnetic laboratory

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

R.L. Coles
Geological Survey of Canada
7 Observatory Crescent
Ottawa, Ontario K1A 0Y3
Telephone: (613) 837-4561
E-mail: rcoles@nrcan.gc.ca

Light stable isotope (LSI) laboratory

This laboratory specializes in the application of oxygen, hydrogen, sulphur and carbon isotope geochemistry to the study of hydrologic, petrologic, and ore-forming processes. A complete range of inorganic and organic Earth materials are analysed as macro and micro samples, using state-of-the-art and, in some cases, world-leading techniques, including laser-based fluorination of microscopic samples. Collaborating scientists from government, industry and university work closely with laboratory personnel. Where appropriate, collaborators may carry out analytical procedures themselves, or rely on support from laboratory staff, on a cost-sharing basis.

B.E. Taylor
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8
Telephone: (613) 995-4673/992-4046
E-mail: btaylor@nrcan.gc.ca

MicroAnalysis laboratory

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

F.C. Thomas
Geological Survey of Canada
P.O. Box 1006,
Dartmouth, N.S. B2Y 4A2
Telephone: (902) 426-4635
E-mail: fthomas@nrcan.gc.ca

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.

S. Irwin
Geological Survey of Canada
101—605 Robson Street,
Vancouver, B.C., V6B 5J3
Telephone: (604) 666-7719
E-mail: sirwin@nrcan.gc.ca

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
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8
Telephone: (613) 995-4686
E-mail: lechemin@nrcan.gc.ca

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.

M.G. Fowler
Geological Survey of Canada
3303—33rd Street N.W.
Calgary, Alberta T2L 2A7
Telephone: (403) 292-7038
E-mail: mfowler@nrcan.gc.ca

Organic petrology laboratory

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

L.D. Stasiuk
Geological Survey of Canada
3303—33rd Street N.W.
Calgary, Alberta T2L 2A7
Telephone: (403) 292-7199
Email: lstasiuk@nrcan.gc.ca

Paleomagnetic laboratory

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

R. Enkin
Geological Survey of Canada
9860 West Saanich Road
Sidney B.C. V8L 4B2
Telephone: (250) 363-6431
E-mail: renkin@nrcan.gc.ca

Paleontology services

GSC paleontologists and laboratory facilities are available nationally and internationally for cost recovery and collaborative activities. 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), analysis of paleontology needs and opportunities, and advice on setting up laboratories and other facilities.

T.P. Poulton
Geological Survey of Canada
3303—33 Street N.W.
Calgary, Alberta T2L 2A7
Tel: (403) 292-7096
E-Mail: tpoulton@nrcan.gc.ca

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.

R. A. Fensome
Geological Survey of Canada
P.O. Box 1006
Dartmouth, N.S. B2Y 4A2
Telephone: (902) 426-2732
E-mail: rfensome@nrcan.gc.ca

International sulphur isotope reference materials

The GSC's Stable Isotope Laboratory has developed a laser-assisted fluorination technique (Micro Isotopic Laser Extraction System – MILES) to analyze sulphides by sulphur hexafluoride that is relatively error free. This technique was demonstrated to the International Atomic Energy Agency (IAEA), which is responsible for maintaining a variety of global isotopic standards. The GSC-developed method for sulphur isotope determination has led to the development of a correction procedure which has been adopted by the IAEA and can be used by all stable isotope laboratories to ensure globally comparable data. It provides a consistency of data which was not previously achievable. Sulphur isotope data has a number of applications including mineral deposits research and the study of paleoclimates.

Radiocarbon (¹⁴C) dating laboratory

The ¹⁴C laboratory provides dating control for many of GSC's surficial mapping and environmental projects. As well, the lab sets national standards and maintains a Canadian ¹⁴C database that may be consulted by Canadian or other researchers. Part of the database is online at <http://sts.gsc.nrcan.gc.ca/radiocarbon>. The laboratory will consider providing dating control for university researchers on a case-by-case basis at a cost per sample.

R. McNeely
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8
Telephone: (613) 995-4241
E-mail: mcneely@nrcan.gc.ca

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.

I. Girard
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8
Telephone: (613) 992-6609
E-mail: igirard@nrcan.gc.ca

Unconsolidated marine sediment laboratory

This laboratory provides access to several user-friendly facilities to measure the physical and visual properties of unconsolidated marine sediments. A state-of-the-art multisensor track utilizes a Cesium 137 source to digitally measure sound velocity, shear strength and water content as well as other physical properties of whole round cores (not split) along their entire length. Additional physical measurements can be taken with an Image x-radiograph system, 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.

K. Robertson or R. Pickrill
Geological Survey of Canada
P.O. Box 1006
Dartmouth, N.S. B2Y 4A2
Telephone: (902) 426-7731
E-mail: kroberts@nrcan.gc.ca

ORGANIZATION



NATURAL RESOURCES CANADA

Minister

The Honourable Ralph Goodale

Deputy Minister

Peter Harrison

EARTH SCIENCES SECTOR

Assistant Deputy Minister

Irwin Itzkovitch

Associate Assistant Deputy Minister

Susan Till

Chief Geoscientist

Richard Grieve

Polar Continental Shelf Project

Geomatics Canada

Geological Survey of Canada

Policy, Planning, Information and Services

Business Development

Sedimentary + Marine Geoscience Branch

Jan Boon

Minerals + Regional Geoscience Branch

Murray Duke

ESS Info

GSC (Atlantic)

Jacob Verboef

Continental Geoscience Division

David Boerner

Management and Administrative Services

GSC (Calgary)

Grant Mossop

GSC (Pacific)

Sandy Colvine

Policy, Planning and Coordination

GSC (Québec)

Aïcha Achab

Mineral Resources Division

John Wood

Terrain Sciences Division

Paul Egginton

FINANCES

Earth Sciences Sector

2000-2001 Expenditures (\$000's)



GEOLOGICAL SURVEY OF CANADA

MINERALS AND REGIONAL GEOSCIENCE BRANCH	SALARY	OPERATING	TOTAL	REVENUE,* COST SHARING
Director General	349	209	558	0
Continental Geoscience	5,412	4,772	10,184	1,721
GSC Pacific	6,396	4,759	11,155	2,669
Mineral Resources	5,866	3,026	8,892	1,727
Nunavut	217	486	703	1,067
Total	18,240	13,252	31,492	7,184

SEDIMENTARY AND MARINE GEOSCIENCE BRANCH

Director General	275	445	720	0
GSC Atlantic	5,661	2,537	8,198	1,386
GSC Calgary	5,947	4,901	10,848	1,429
GSC Québec	1,853	2,478	4,331	570
Terrain Sciences	4,669	4,987	9,656	1,129
Total	18,405	15,348	33,753	4,514

TOTAL GSC	36,645	28,600	65,245	11,698
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GEOMATICS CANADA	32,377	34,841	67,218	26,667
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POLAR CONTINENTAL SHELF PROJECT	689	2,968	3,657	2,602
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CORPORATE SERVICES**

Executive Services***	1,849	1,427	3,276	0
Policy, Planning, Information and Services	8,765	5,970	14,735	260
Grants and Contributions			6,770	
Total Corporate Services	10,614	7,397	24,781	260

TOTAL SECTOR	80,325	73,806	160,901	41,227
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* Includes additional funds from intellectual property, vote-netted revenue, revolving fund, specified purpose accounts, and transfers from other government departments.

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

*** Includes Business Development Office.

How to order GSC products

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

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

The online GSC Information Circular at www.nrcan.gc.ca/gsc/gicd/pubs/circur_e.html announces the release of new reports, maps and open files. To receive an electronic notification for each monthly Circular, please contact the GSC Bookstore in Ottawa.

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

HOW TO REACH US

Nova Scotia/Atlantic Canada

Geological Survey of Canada
1 Challenger Drive, P.O. Box 1006
Dartmouth, N.S. B2Y 4A2
Telephone: (902) 426-3225
Fax: (902) 426-1466
E-mail: agc@agc.bio.ns.ca

Quebec

Geological Survey of Canada
Québec Geoscience Centre
880 Chemin Sainte-Foy
P.O. Box 7500
Sainte-Foy, Quebec G1V 4C7
Telephone: (418) 654-3162
Fax: (418) 654-2615
E-mail: aachab@nrcan.gc.ca
Bookstore: (418) 654-2677

Ontario

Geological Survey of Canada
(Headquarters)
601 Booth Street
Ottawa, Ontario K1A 0E8
Telephone: (613) 996-3919
Fax: (613) 943-8742
E-mail: esic@nrcan.gc.ca
Bookstore:
Telephone: (613) 995-4342
Toll-free long distance (Canada and U.S.)
1-888-252-4301
Fax: (613) 943-0646
E-mail: gsc_bookstore@gsc.nrcan.gc.ca
Website: www.nrcan.gc.ca/gsc/bookstore/

Alberta/Prairies

Geological Survey of Canada
3303-33rd Street N.W.
Calgary, Alberta T2L 2A7
Telephone: (403) 292-7000
Fax: (403) 292-5377
E-mail: calgary@gsc.nrcan.gc.ca
Website: www.nrcan.gc.ca/gsc/calgary
Bookstore:
Telephone: (403) 292-7030
Fax: (403) 292-3542
E-mail: gsc_calgary@gsc.nrcan.gc.ca

British Columbia

Geological Survey of Canada
Suite 1600-605 Robson Street
Vancouver, B.C. V6B 5J3
Telephone: (604) 666-0529
Fax: (604) 666-1124
E-mail: gscvan@gsc.nrcan.gc.ca
Bookstore:
Telephone: (604) 666-0271
Fax: (604) 666-1337
Library:
Telephone: (604) 666-3812
Fax: (604) 666-7186
9860 West Saanich Road
Sidney, B.C. V8L 4B2
Telephone: (250) 363-6500
Fax: (250) 363-6565

Nunavut

Canada-Nunavut Geoscience Office
P.O. Box 2319
Iqaluit, Nunavut X0A 0H0
Telephone: (867) 979-3539
Fax: (867) 979-0708
E-mail: djscott@NRCan.gc.ca