GEOLOGICAL SURVEY OF CANADA

1989-1990

Canada

Cover: A unique Circumpolar geological map of the Arctic at the 1:6 million scale was published in the fall of 1989. The compilation represents the collaborative work of GSC scientists and their Soviet colleagues under the Canada/USSR Arctic Exchange Agreement.

The very tight production schedule was met by an enthusiastic team effort that drew on the expertise of scientific, cartographic and technical staff from the GSC's offices in Calgary, Ottawa and Dartmouth and from private contractors in Montreal and Dartmouth.

Copies of the map are available from all GSC sales outlets (see directory on page 24 for addresses). Photo: K. Hale, GSC.

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A Message from the Assistant Deputy Minister Geological Survey of Canada

P. Thériault, GSC

Hamilton Peninsula, Ellesmere Island, Northwest Territories.

Cooperation, collaboration, joint ventures, cost sharing—these words are rapidly becoming the starting point for any new research project. They are, in fact, the basic vocabulary of the scientific community of the 1990's.

We operate in a time of tight government expenditures and spiralling research costs, and we have had to adjust accordingly. While difficult, the effect of this has been positive. Scientific organizations in all sectors of the economy—whether industry, university or government—have had to start pooling resources to accomplish research objectives. The results are proving to be very exciting. Scientists from diverse disciplines and agencies are now sharing concepts and ideas, and

this "cross fertilization" is breathing new life into all kinds of joint enterprises.

The Geological Survey of Canada has traditionally been a strong proponent of cooperative research and has over the years spearheaded Canada's contribution to many important national and international collaborations: LITHOPROBE, the Ocean Drilling Program, the Canada/USSR Arctic Science Exchange—these are but a few of the more recent examples.

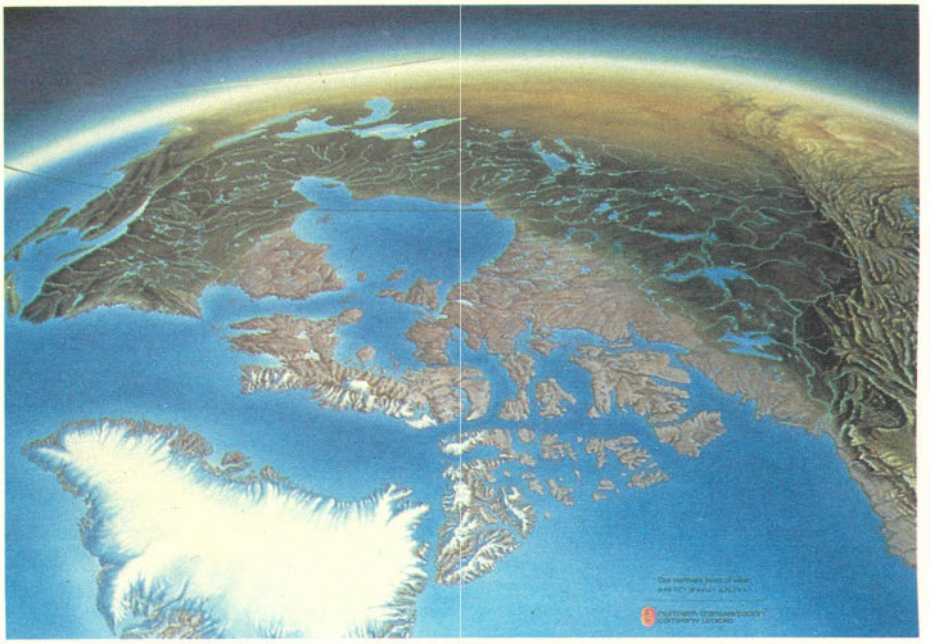
To maximize the science we can "buy" with our limited research dollars, we are now stepping up our efforts to develop cooperative research ventures. In the pages that follow you will find many examples of this, but I would particularly like to draw to your attention a few initiatives that will have a major impact on the state of national geoscience.

A key recommendation of the 1989 Mines Ministers Conference was that federal and provincial/territorial geological surveys work more closely together to strengthen coordination of their research. In response senior Survey officials, during the past year, met one on one with their provincial counterparts with the result that mechanisms for improved coordination of effort are now in place.

Significant progress has been made in the past year in implementing a national geoscience mapping program (NATMAP). Industry, university and government participants have set lofty objectives for this cooperative program: to improve the quality, relevance and completeness of the geological database needed to address societal concerns relating to the environment, natural hazards and resource development.

Over the past year, we also saw growing demands for the geoscience data necessary to understand many environmental issues. The Survey is taking a new look at existing data from ice and sediment cores with a view to helping establish baselines against which global changes can be determined or assessed. And we are making this information available to all researchers working on environmental questions.

Knowledge of the energy-rich Western Canada Sedimentary Basin will be enriched by the work of a consortium of GSC and six major oil companies (Amoco Canada, Canadian Hunter, Esso Resources, Mobil Oil, Pan Canadian Petroleum, Petro-Canada). Joint aeromagnetic work will provide data to all participants at a moderate cost, and under the terms of the agreement GSC will make all data public after five years.



Northern Transportation Co. Ltd.

Canada, a polar nation shown from a polar perspective.

We also have high hopes for our new multidisciplinary EXTECH (Exploration Science and Technology) program. Its aim is to improve concepts and technologies applicable to mineral exploration. Initial results of a pilot project in the Snow Lake area of Manitoba, involving collaboration with provincial and industry scientists, have been very promising for the exploration for massive base metal sulphide deposits.

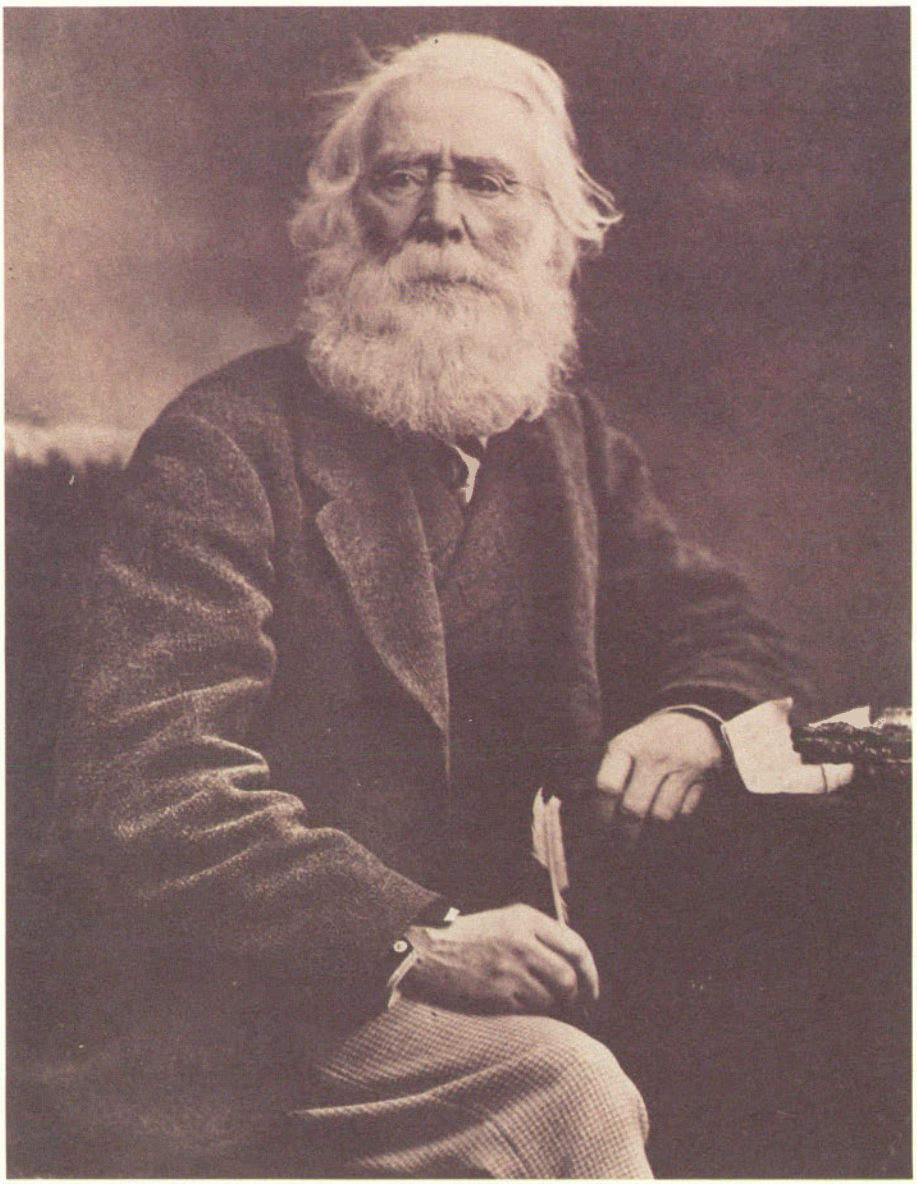
These are just a few examples out of many. In the pages that follow you will find described many other exciting cooperative projects. This new age of working together is bringing us all benefits; but most important it is the state of geoscience research in Canada that will be the winner in the long run.

Elkanah A. (Ken) Babcock

Geological Survey of Canada : Introduction

Traditions of excellence

Since its founding in 1842, the Geological Survey of Canada has provided Canadians with the best possible geoscientific knowledge, technology and expertise about Canada and its offshore, its mineral and energy resources, and the natural conditions that affect land and seabed use.



GSC Photo Library

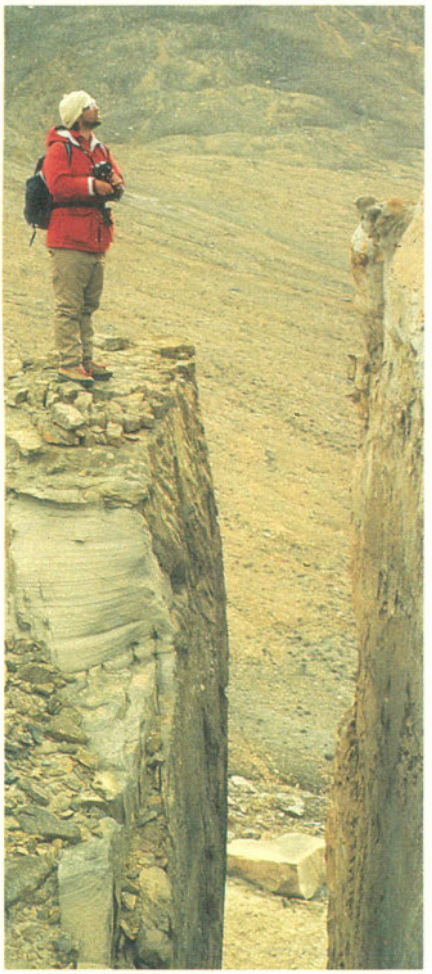
Sir William Logan, founder and first director (1842-1869) of the Geological Survey of Canada.

People are our Future

The strength of an organization like the Geological Survey of Canada lies in the expertise and capabilities of its highly trained and motivated staff. To maintain that strength, GSC hires the best young earth scientists available and strives to support its staff by encouraging new challenges, work exchanges and conference participation.

Creating a top-flight cadre of Canadian geoscientists has long been a concern of the GSC, and this has resulted in a tradition of hiring about 300 students for field work each summer. Efforts have recently been enhanced by a "Young Scientists" Program that allows young researchers to "shadow" senior scientists who are authorities in their field, with the goal of developing a continuity in achievements already made.

As part of its outreach to the francophone community, the GSC is continuing to expand its Quebec office, making sure that it provides work opportunities across Canada and is fully involved in GSC's national programs. Positive steps are also being taken to support and actively promote the contribution of women in science and management.



B. Beauchamp, GSC

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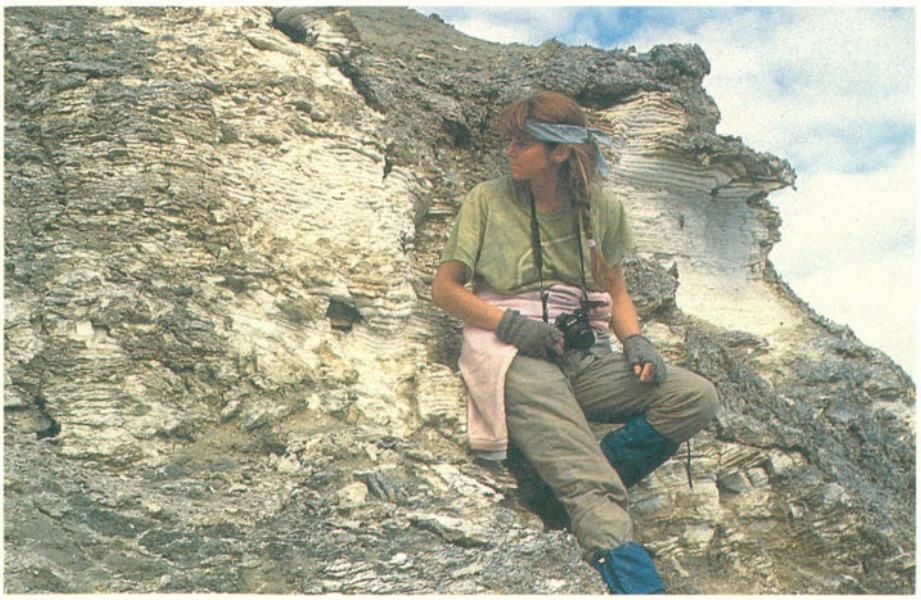

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B. Beauchamp, GSC

GSC students on the job: (a) Jonathan Devaney looking at trace fossils in Lower Permian Sabine Bay formation, Hamilton Peninsula, Ellesmere Island. (b) Carol Wallace examining laminated evaporites of Early Permian age, Mount Bayley Formation, Ellesmere Island.

Contributing to a strong Canada

The implications of the Survey's work are far-reaching and make an important contribution to the high standard of living that Canadians enjoy. To give just a few examples:

- ***Economic development:*** information about the nature and location of our oil, gas and mineral resources is crucial to the continued well-being of the energy and mining communities;
- ***Public safety:*** assessments of natural hazards such as earthquakes are fundamental to setting safe building codes and for rational land use planning;
- ***Environmental protection:*** studies of natural phenomena such as permafrost form the basis for safeguarding fragile environments when development is being considered.
- ***Sovereignty:*** the provision of logistical support for polar science enables more than 1,000 Canadian researchers to work in the High Arctic each summer.

The Survey's high standards and traditions of excellence are nationally and internationally recognized, as is its impressive track record for promoting multi-disciplinary, cooperative work.

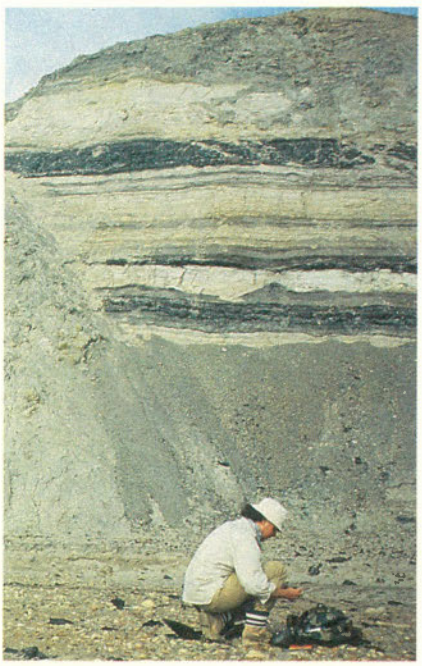
J. Pilon, GSC

Pipeline monitoring on the Norman Wells-Zama pipeline using Ground Probing Radar EKKO III to delineate the boundary between the active layer and permafrost. Paul Lafleche, Alan Judge and Jean Pilon are shown in the photo.

Truly a national presence

The Survey's research facilities are located in Dartmouth, Nova Scotia; Sainte-Foy, Quebec; Ottawa, Ontario; Calgary, Alberta; and Vancouver and Sidney, British Columbia. Base camps for supporting Arctic research are maintained by the Polar Continental Shelf Project at Resolute and Tuktoyaktuk, Northwest Territories, and on an ice island in the Arctic Ocean. Observation facilities for national seismological, geomagnetic and geodynamic research are found throughout Canada. Field work is carried out both onshore, often in Canada's most remote corners, and offshore.

Program Highlights



Y. Michaud, GSC

The Quebec Geoscience Centre conducts surficial geology surveys in northern and eastern Canada; these provide a basis for future environmental and engineering geological studies. Shown here, Christian Bégin studying quartzitic sandstone showing veins of coal, Fosheim Peninsula, Ellesmere Island.

The research of the Survey underpins key economic and policy objectives of government. With the intention of providing a clear, logical link between the activities of the Survey and the societal or client needs that they serve, a new program structure was developed and adopted in September 1989. The six main program elements are geoscience surveys, energy, minerals, environment, information, and Arctic logistics. The highlights of the 1989-90 research program that follow are grouped accordingly.

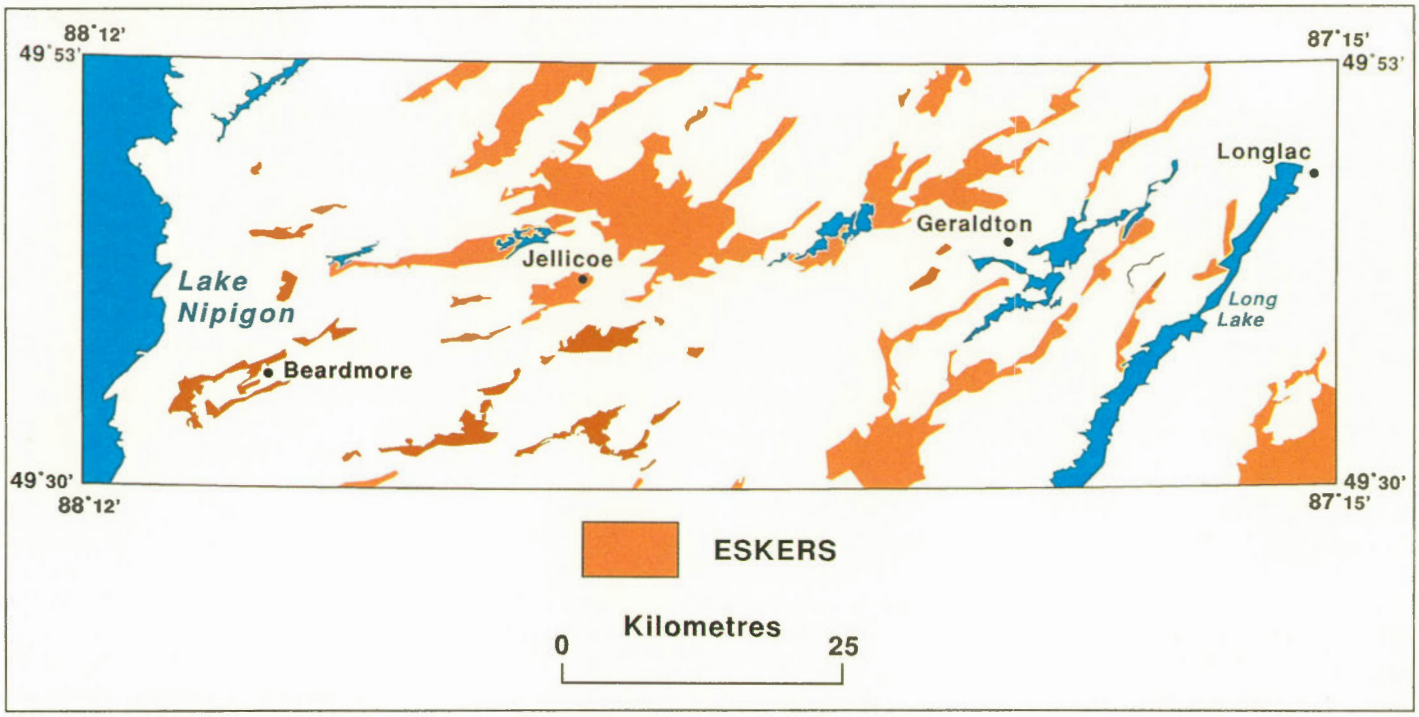
Geoscience Surveys

▶ Consultation with provincial and territorial counterparts and a workshop held in Toronto in March 1990 with industry, university and government participation defined the scope and objectives of an important new initiative called the National Geoscience Mapping Program (NATMAP). NATMAP is a cooperative, multidisciplinary program to improve the quality, relevance and completeness of bedrock and surficial geological maps and database coverage. An interim steering committee has been set up to implement NATMAP.

▶ In the Appalachian region of Quebec and Newfoundland, work from the Quebec Geoscience Centre focused initially on structural and sedimentological investigations with a view to establishing a framework for metallogenic studies. Work in the Grenville geological province was begun to identify critical geological units and tectonostratigraphic packages in Laurentide Park between Quebec City and Chicoutimi. Two other new projects will involve collaboration with the Ministry of Energy and Resources of Quebec—one will investigate the tectonic significance of the Bostonnais Complex in Mauricie Region; the other will study geological relationships between parts of the Grenville metasedimentary belt in Western Quebec (Mont Laurier region) and Ontario.

Every summer GSC geologists carry out field work in remote areas of Canada. This striking picture of a typical base camp in eastern Boothia Peninsula, Northwest Territories, won first prize in the 1989 GSC Photo Contest for its photographer, Tom Frisch.

▶ GSC continued its commitment to the national LITHOPROBE program which aims to "map" the third dimension beneath the Canadian landmass and its surrounding oceans. Of particular note: a seismic reflection survey in Newfoundland that will provide new insight into the structure of the Appalachians, and a seismic refraction survey in British Columbia in collaboration with the U.S. Geological Survey and Canadian universities. LITHOPROBE's success has also stimulated joint ventures with industry. For example, during the Newfoundland survey, BP Canada Inc. partially funded and provided logistic support for work at Buchans Mine; interpretation of the survey results will lead to a better understanding of the geology of the region.



F.J. Kristjansson, OGS and L.H. Thorleifson, GSC

As part of the Canada/Ontario Mineral Development Agreement (COMDA), GSC and the Ontario Geological Survey worked together on surficial mapping and drift prospecting research in Northern Ontario's Beardmore-Geraldton area. Shown here is the extent of ice contact glaciofluvial sediments such as eskers. Data on gold, base metal and kimberlite indicator distribution in the drift, as well as an account of the ice flow history in the area accompany the map.

▶ New multichannel seismic reflection profiles gathered by the GSC across the Juan de Fuca Ridge, off Canada's West Coast, are providing insight into this very active seafloor spreading centre and its fascinating associated seafloor sulphide deposits. The profiles will help guide the final siting of holes that are to be drilled in this area in 1991 by the Ocean Drilling Program.

▶ Other new multichannel seismic reflection profiles off Vancouver Island allowed GSC scientists to "see" to depths of 25 km into the Cascadia Subduction Zone (where the Juan de Fuca tectonic plate sinks beneath North America). The principal fault contact between the crust of the Pacific Ocean and the overriding North American continent lies just off Vancouver Island,

and is remarkably well imaged by the new data. It is along this fault that large magnitude earthquakes may occasionally occur.

▶ Some 5,600 line-kilometres of gravity and bathymetry data were collected in a marine survey of Lake Huron and Georgian Bay, and along seismic profiles in lakes Michigan and Huron in a cooperative project (Great Lakes International Multidisciplinary Program on Crustal Evolution – GLIMPCE) involving the U.S. Geological Survey, Canadian Hydrographic Service and Canada Centre for Inland Waters. A preliminary Bouguer gravity anomaly map has been produced, and the gravity data will be used along with existing aeromagnetic and seismic data sets to derive integrated models of crustal structure beneath Lake Huron.

▶ In the Yukon, the Glenlyon map sheet was completed. Field investigations in the Carmacks area led to the documentation of a large 1850 earthquake, the oldest historic earthquake in the Yukon, and provided evidence for the eruption of Volcano Mountain between 100 and 300 years ago. Understanding of these catastrophic geological events is critical to resolving planning and safety issues.

▶ The world's oldest terrestrial rocks were discovered in the Northwest Territories. Their age of about 4 billion years old makes the rocks just a bit younger than the moon which is 4.6 billion years old.

Energy

▶ GSC and six major oil companies (Amoco Canada, Canadian Hunter, Esso Resources, Mobil Oil, Pan Canadian Petroleum, Petro-Canada) signed an agreement in January 1990 to undertake a high resolution aeromagnetic survey of southern Alberta. The survey will help determine the relationship between basement structure and sediments in the energy-rich Western Canada Sedimentary Basin and provide the data to all participants at a moderate cost. The survey work will be carried out over the next three or four years. Under the agreement, GSC will make the data public after five years.

▶ Preparations for a quantitative assessment of the Western Canada Sedimentary Basin's natural gas resources is well underway: the delineation of Devonian gas plays in the western and northern segments of the basin is nearing completion, with work proceeding toward completing Devonian plays throughout the entire basin in 1990.

▶ The development of sedimentary basins over geological time is accompanied by the development of stress fields from the weight of sediments and from crustal forces acting upon the sedimentary basin. The magnitude and direction of the stress fields have been shown to influence both the accumulation of hydrocarbons and the most effective means for extracting them.

EMR

GSC scientists are involved in a major collaborative venture with over 150 scientists from industry, government, and universities to produce a definitive geological atlas of the energy-rich Western Canada Sedimentary Basin.

In 1989, GSC helped develop maps showing the distribution and magnitude of stress in Canadian sedimentary basins. There is growing interest in this topic for the Western Canada Basin particularly as it relates to the design and implementation of suitable enhanced recovery techniques.

- In the western Arctic, modeling of seismic refraction data recorded from the ice island indicated the presence of hitherto unknown major sedimentary basins containing at least 12 km of sedimentary strata along the northwest coast of Ellesmere Island. Initial studies suggest that the basins may be similar to Beaufort Sea basins, with the implication that they too could be sources of oil and gas. GSC research also resulted in a new understanding of the hydrocarbon potential of the Bowser Basin, in northwestern B.C., and the Chilcotin-Nechako Basin.

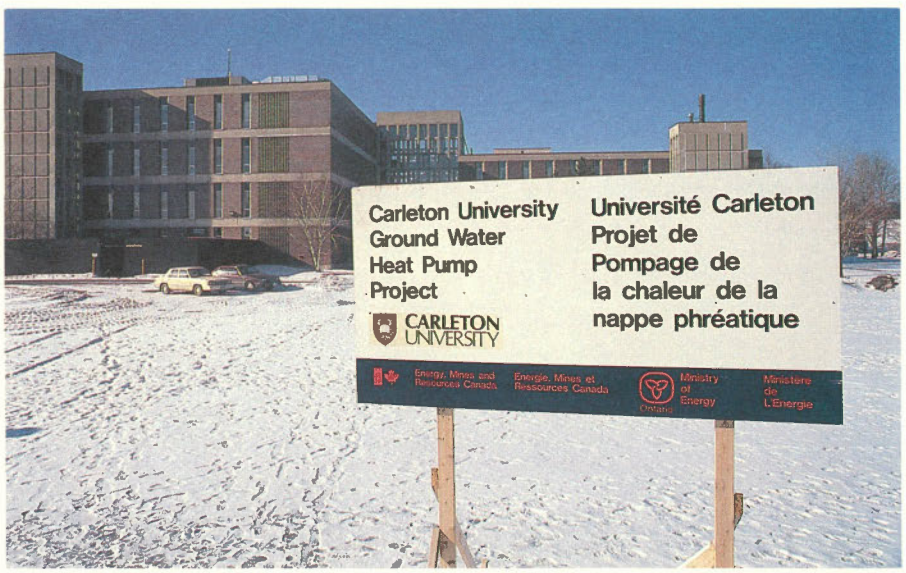
- GSC scientists collaborated with colleagues at the Institut Français du Pétrole in applying the computer-based THEMIS model of basin evolution and hydrocarbon maturation and migration to the Williston Basin in southern Saskatchewan, North Dakota and Montana.

Minerals

▶ Borehole logging investigations were conducted in close cooperation with mining companies in Bathurst, New Brunswick; Kemptville and Moose River, Nova Scotia; and Timmins, Ontario. At Timmins, demonstration of an innovative "mise-à-la-masse" method (a type of down borehole geophysical test) resulted in a significant increase in estimated reserves of the Redstone Nickel Deposit.

▶ Detailed geological mapping in the Northwest Territories yielded important information on mineral potential by elucidating the structure and stratigraphy of two greenstone belts—one in the Tehek Lake-Meadowbank River area north of Baker Lake, the other near Rankin Inlet. These studies allow units containing stratabound gold or major Archean shear zones to be explored more effectively.

▶ Seafloor minerals research continued to build momentum with the announcement that submarine massive sulphide deposits on the Juan de Fuca Ridge will be drilled in 1991 as part of the international Ocean Drilling Program. A major accomplishment this year was the successful sampling and analysis of sediment pore waters around seafloor hydrothermal vents. The chemical gradients observed in these fluids provide new understanding of hydrothermal alteration



EAETB/CANMET

The GSC's unique capabilities in borehole logging were employed to assist in the development of a groundwater heat pump system for Carleton University in Ottawa. The system, now in operation, is expected to reduce the university's fuel bills by $450,000 a year.

G. Lemieux, GSC

An integrated, multidisciplinary project to improve concepts and technologies applicable to massive base metal sulphide exploration was initiated in the Snow Lake area of Manitoba. The goal of the EXTECH (Exploration Science and Technology) project is to develop integrated deposit models, enhanced airborne, ground and borehole geophysical techniques, surficial geochemical methods and GIS (Geographic Information System) data integration techniques. An important initial result of the Snow Lake studies was the identification of a zinc-rich stratigraphic marker capping the Chisel Lake orebody. Shown here, Ramesh Reddy, Ray Hetu, Danny Wright, Bill Coker and Doreen Ames of the EXTECH multidisciplinary team.

patterns associated with the important SEDEX class of lead-zinc deposits. This in turn may be directly translated into new exploration criteria.

- In Quebec, detailed mapping of sulphide deposits of the Upton and Acton Vale areas in the Eastern Townships was carried out. Work on exhalites and sulphide mineralization associated with black shales of this region is continuing. In the Grenville Province studies of the extension of Archean greenstone belt rocks (Abitibi Belt) into the Grenville have begun, with the objective of identifying favourable zones for base metals exploration.

- As part of its ongoing program to revise obsolete geological maps, GSC scientists discovered that gold bearing strata associated with the rich Eskay Creek gold prospect in British Columbia extend at least 50 km north and south of the discovery. This horizon was previously unrecognized as having any economic potential for precious metal mineral deposits.

- In a one-year cooperative mapping project in the Yukon, geologists from GSC and the Department of Indian Affairs and Northern Development made two important mineral discoveries of base metal deposits (lead and zinc sulphides). Logistics coordination with a geological consulting company working in the region allowed field work for three 1:50,000 map areas to be completed in just three months.

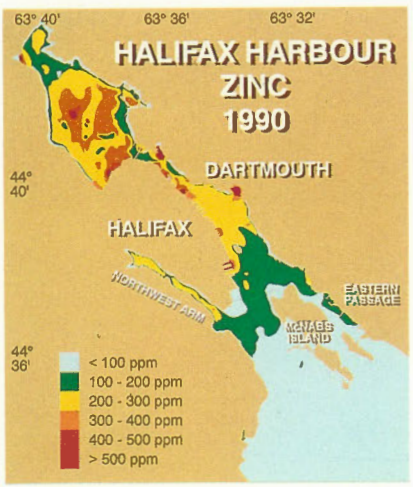
Environment

▶ GSC started a new environmental geochemistry initiative involving baseline geochemical data, natural radioactivity, natural acidity, and hydrogeology. Examples of work underway include: an evaluation with the Saskatchewan Department of the Environment and Public Safety of a potential problem associated with the decommissioning of open pit uranium mines; airborne and ground radioactivity mapping to determine the potential radon hazard in buildings on various soil types in southern Manitoba; a study with Health and Welfare Canada to evaluate potential radon hazards on Indian reserves across Canada; and analysis to determine the extent of contamination from arsenic used in wood preservatives on childrens' play structures.

▶ The GSC operates a national network of seismological observatories to monitor seismicity and assess earthquake hazard. Of particular note, eastern Canada's largest earthquake for 65 years took place Christmas Day, 1989, in the unpopulated interior of the Ungava peninsula of northernmost Quebec. It was felt quite strongly in isolated coastal communities but no damage was reported. Seismic data has many other applications; for example, data from GSC's seismograph station in Inuvik have been used to help the inquiry into the fatal CF-18 crash which took place on January 29 near Inuvik

R. Belanger, Bedford Institute

GSC, Fisheries and Oceans, and Environment Canada released a joint report on the marine environmental quality of Halifax Harbour. The results show that the degree of heavy metal contamination in the harbour is greater than that of others in eastern Canada. It also indicates, however, that most of the metals are bound in the sediments and are insoluble under present conditions. Research continues to determine the extent to which these metals may be remobilized by the implementation of a proposed sewage treatment system.



D. Buckley and K. Hale, GSC

Distribution of total zinc metal in uppermost one centimeter of sediments of Halifax Harbour. Highest concentrations of this contaminant are found in Bedford Basin and adjacent to industrial sites, land disposal sites and major sewer outfalls.

Airport. GSC provided the Board of Enquiry with an analysis of the seismic recording that demonstrated that the impact and explosion occurred simultaneously.

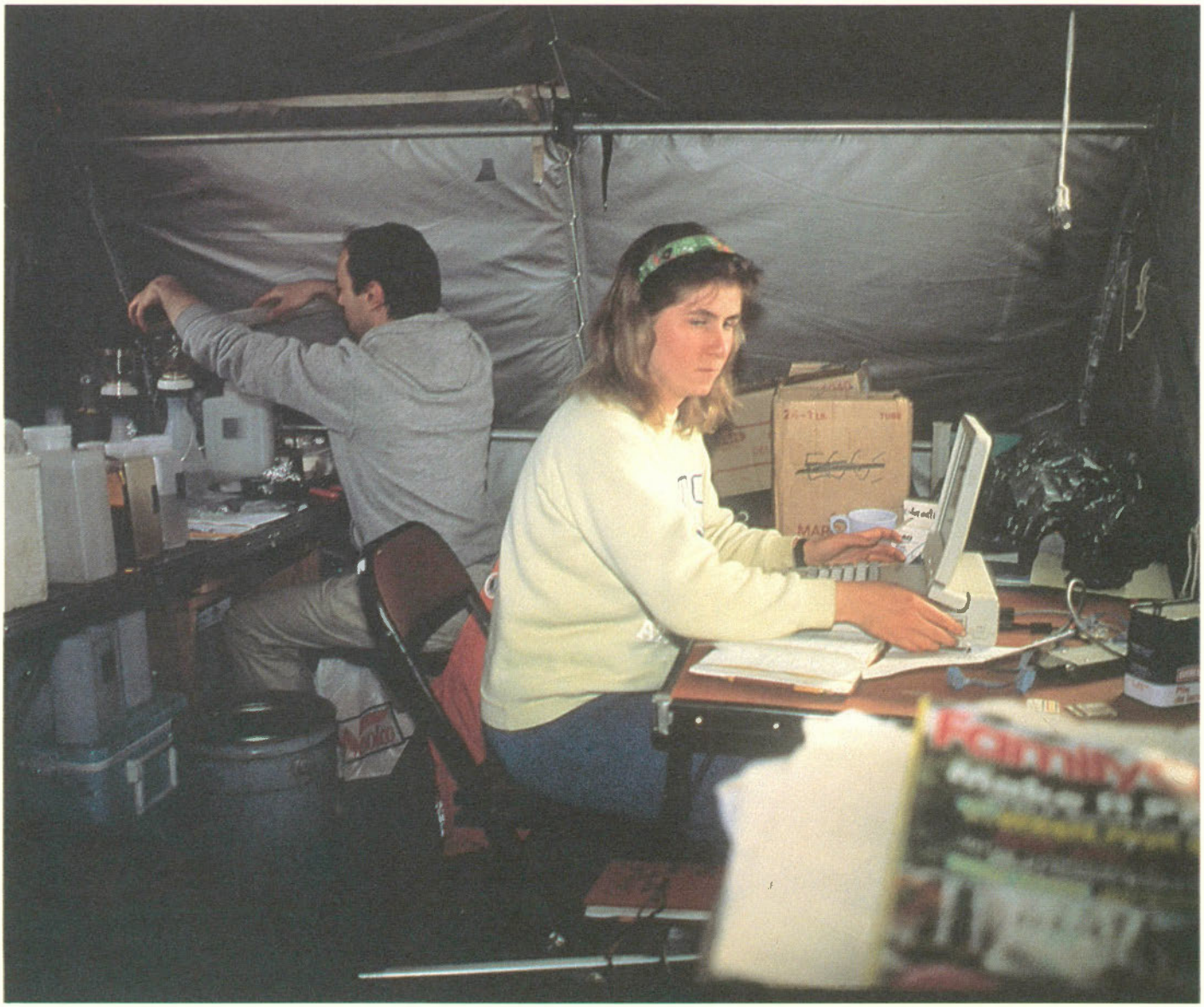
▶ GSC carried out the first stage of an onshore-offshore mega-transect of the Beaufort Sea coastal zone in March 1990. This multi-disciplinary investigation of permafrost, surficial geology and geotechnical conditions of the Beaufort Shelf is taking place in the area of a proposed pipeline from the Amauligak oil field.

▶ Recent volcanological studies and geological mapping in western North America suggest that a volcanic eruption can be expected somewhere within the Canadian Cordillera within the next 100 years. GSC has started work on an appropriate response plan.

▶ The geological record is a crucial baseline of past environmental change from which we can reconstruct past global change, monitor contemporary change, and predict future impacts. The GSC, therefore, has an important contribution to make to the international Global Change initiative. During 1989-90, GSC set up a second Global Change "observatory" in the Mackenzie Valley to complement the one at Hot Weather Creek on Ellesmere Island. In both areas environmental variables affecting vegetation distribution, rates of geomorphic change, ground ice conditions and permafrost are monitored, recorded, and analyzed.

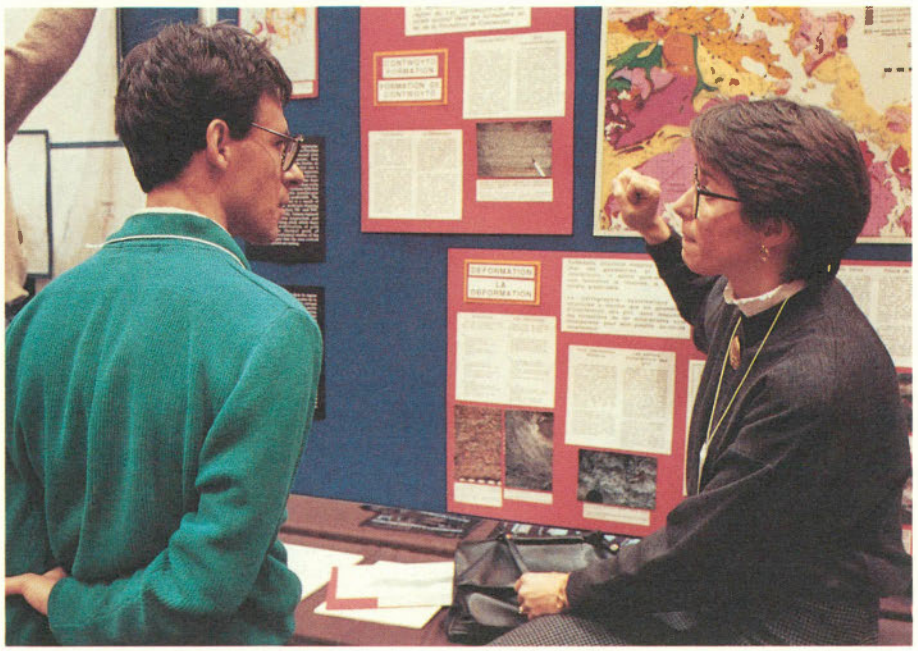
▶ Data compilation and interpretation have begun for a series of paleoenvironmental maps (of selected time intervals) for northern North America depicting oceanographic data and the distribution of glacial ice, seas, major lakes, vegetation, and permafrost zones. The maps, which are based on an extensive paleoecological database, will be a useful guide to evaluating future changes in regional environmental conditions. Another series of maps will depict the possible effects of environmental changes on geological processes and the potential impact on the Canadian landmass.

▶ A GSC/university/industry team has made a discovery that may have important archaeological implications. While studying a sediment core from the continental shelf seafloor just north of Vancouver Island, they found the first incontrovertible evidence that the sea level in this area was at least 95 m lower relative to land 10,500 years ago. The results also indicate that when the sea level rose it did so with unusual rapidity. If humans were present on the West Coast 10,000 to 11,000 years ago, as seems likely, they may have occupied large areas of the continental shelf that are now covered by the sea.



D. St-Onge, GSC

Field assistant Kelly Thompson (foreground) works in the field laboratory of GSC's Global Change Observatory at Hot Weather Creek, Ellesmere Island, entering soil hydrology data in a laptop computer charged by solar panels. Paul Hamilton, a researcher with the National Museum of Nature, is processing lake and pond water samples.



R. De Launais, GSC

FORUM 1990, Ottawa, Ontario— Janet King discusses her research with Dan Kontak, Nova Scotia Bureau of Mines.

Information

▶ The GSC's Annual Current Activities Forum, held in Ottawa, January 1990, took the Arctic as its theme. Timed to coincide with the first ever Minerals Colloquium, the two events attracted a combined audience of over 900 with substantial representation from both industry and the universities. The 1989 Western Canada Coal Geoscience Forum, co-sponsored by GSC, Alberta Geological Survey, and B.C. Geological Survey, was another major venue for information exchange.

▶ GSC scientists participated in a popular series of public lectures on "Geological Hazards in British Columbia", sponsored by the Vancouver Natural History Society and the Geological Association of Canada. The talks covered earthquakes, volcanoes, landslides, and the potential effects of global warming on coastal stability and mountain floods.

▶ A special issue of the science quarterly GEOS, based on papers written by GSC scientists, provided an overview of the GSC's contribution to Global Change research. It has been enthusiastically received by the scientific community and the public.

▶ Cooperation between GSC, provincial geological surveys and the National Geological Surveys Committee resulted in the new Canadian Geoscience Data Directory. This useful compilation is a significant addition to computer-based literature.

International Cooperation

▶ The very successful Canada/USSR Arctic Science Exchange Agreement was extended for another two years with the negotiation of a new Protocol in September 1989 in Leningrad. Collaboration under the program resulted in the production of an important Circumpolar geological map of the Arctic at the 1:6 million scale (see cover illustration). Nearing completion were jointly produced paleogeographic maps and correlation charts of the Arctic circumpolar region; these will provide a valuable resource for interpretation of the development of the Arctic Ocean Basin. Another achievement was a Quaternary map of the land portion of North America; this will be integrated

into a Quaternary map of the Arctic to be published with the Soviets.

- GSC provided scientific supervision to Canadian International Development Agency (CIDA)-funded airborne geophysical surveys in Thailand and Zimbabwe. Both projects were successfully completed during the year, and resulted in substantial contract revenues for the Canadian geophysical service industry.

- Working with the Pan American Institute of Geography and History (PAIGH), the GSC is involved in a series of informal bilateral agreements with various Latin American countries to help produce their national gravity maps. The gravity map of Venezuela, published recently by the Universidad Simon Bolivar and the Direccion de Cartografia Nacional, is the first of this series. The second, for Bolivia, is in production.

Sharing across the Border: Canada/U.S. Cooperation

Geology knows no political boundaries. As a result, collaboration between the Geological Survey of Canada and the U.S. Geological Survey (USGS) has become so pervasive as to be almost taken for granted. Both countries have benefitted immensely from this sharing of work and expertise.

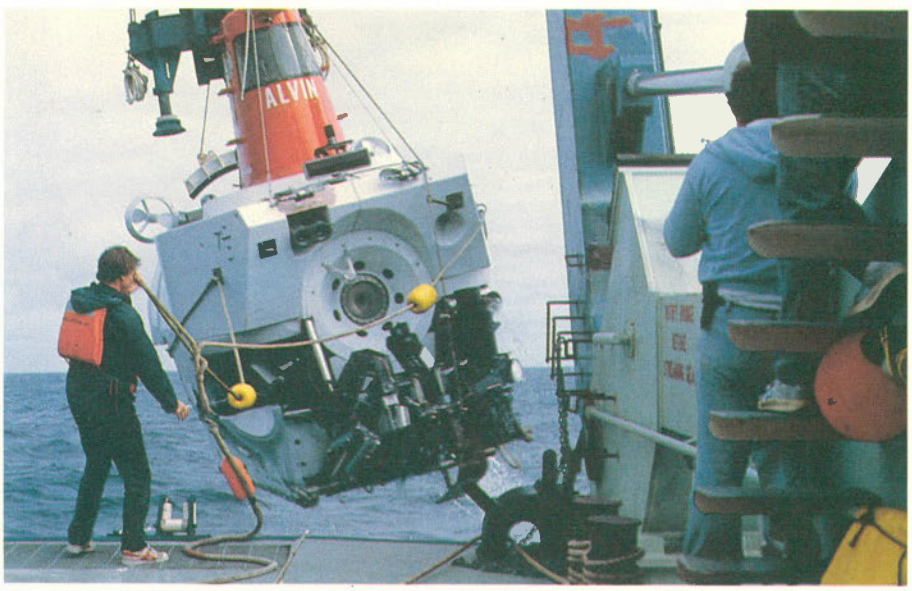
A major achievement has been a joint study of the deep structure beneath the Great Lakes, giving us a new understanding of the geological structure of this unique area. Exchanges of data, equipment and personnel ensured that the maximum science was obtained at a reasonable cost. The spectacular delineation of a mid-continental rift structure that resulted from this work has attracted world-wide attention. Other examples include:

- **Joint geological and geochemical mapping has started or is being planned along our shared boundaries (e.g. Alaska-Yukon, Quebec-Maine). Joint comparative studies of particular types of mineral occurrence are underway.**

- **An ongoing pooling of seismic refraction instrumentation has seen USGS scientists working in southern British Columbia and GSC scientists in Alaska.**

- **Joint planning, particularly for Arctic studies, is a frequent occurrence.**

- **On the west coast, cooperative studies of the Cascadia subduction zone are an essential to understanding its history and will perhaps shed light on future seismic activity in this area.**



I. Jonasson, GSC

Canada/U.S. cooperation: Shared offshore work on the underwater Juan de Fuca Ridge is making the best use of the highly specialized equipment required and costly ship time. Shown here, the recovery of the U.S. submersible "Alvin" following a joint cruise.

M. Cecile, GSC

As part of continuing collaboration of Canadian and Soviet scientists under the Canada/USSR Arctic Science Exchange Agreement, Hans Trettin, GSC, points down Yelverton Pass, northern Ellesmere Island, and explains to Soviet colleagues, Boris Lopatin (left) and Michael Kos'ko how the exotic Pearya Terrane docked with Arctic Canada.

Research Grants

▶ Funds available to the EMR Research Agreements Program increased by 50% (to $2 million) following the successful negotiation of a cooperative financial arrangement with the Natural Sciences and Engineering Research Council. As a result, the program, which GSC administers on behalf of EMR, was able to award 209 grants for 1990 to recipients in 39 research centres across Canada—a significant increase from last year's 178 grants.

Polar Continental Shelf Project

The Polar Continental Shelf Project (PCSP) runs a sophisticated logistics network that allows scientists to conduct research safely and efficiently in the Canadian Arctic. PCSP experienced one of its busiest field seasons in 1989. It provided logistics support to 220 science research groups from federal and territorial agencies and Canadian universities, and to 13 artists working under the Arctic Awareness Program, sponsored jointly by PCSP and the Canada Council.

▶ With the completion of a major two-year renovation and reconstruction of its base facilities at Resolute and Tuktoyaktuk this year, PCSP is now well placed to meet the growing challenges of supporting science in the Canadian Arctic beyond the turn of the century.

▶ The Ice Island Research Station was also upgraded. A cooperative National Research Council-Memorial University ice structure study was conducted from this unique research platform, adrift in the Arctic Ocean.

▶ Other major projects supported by PCSP included a climatology-vegetation-soil hydrology study at GSC's High Arctic Global Change Observatory at Hot Weather Creek on Ellesmere Island; completion of a GSC/Fisheries and Oceans reconnaissance bathymetry survey north of Parry Channel; wildlife studies by the Yukon and North-

B. Hrycyk, PCSP

Adrift in the Arctic Ocean, the Ice Island Research Station provides scientists from many diverse fields a unique opportunity to study this relatively unknown region. Shown here, komatiks (sleds) on "Main Street", Ice Island.

west Territories governments and the Canadian Museum of Natural Sciences; and the Canada-China Dinosaur Project.

- PCSP, Atmospheric Environment Service and Parks Canada initiated a long term cleanup project in the Arctic, with the removal of 4,800 empty oil drums from Eureka on Ellesmere Island; these were returned south for recycling.

For more information, contact:

Polar Continental Shelf Project
Room 6128, 344 Wellington Street
Ottawa, Ontario
K1A OE8

Telephone: (613) 990-6990
Fax: (613) 990-1508

M. Nobert, PCSP

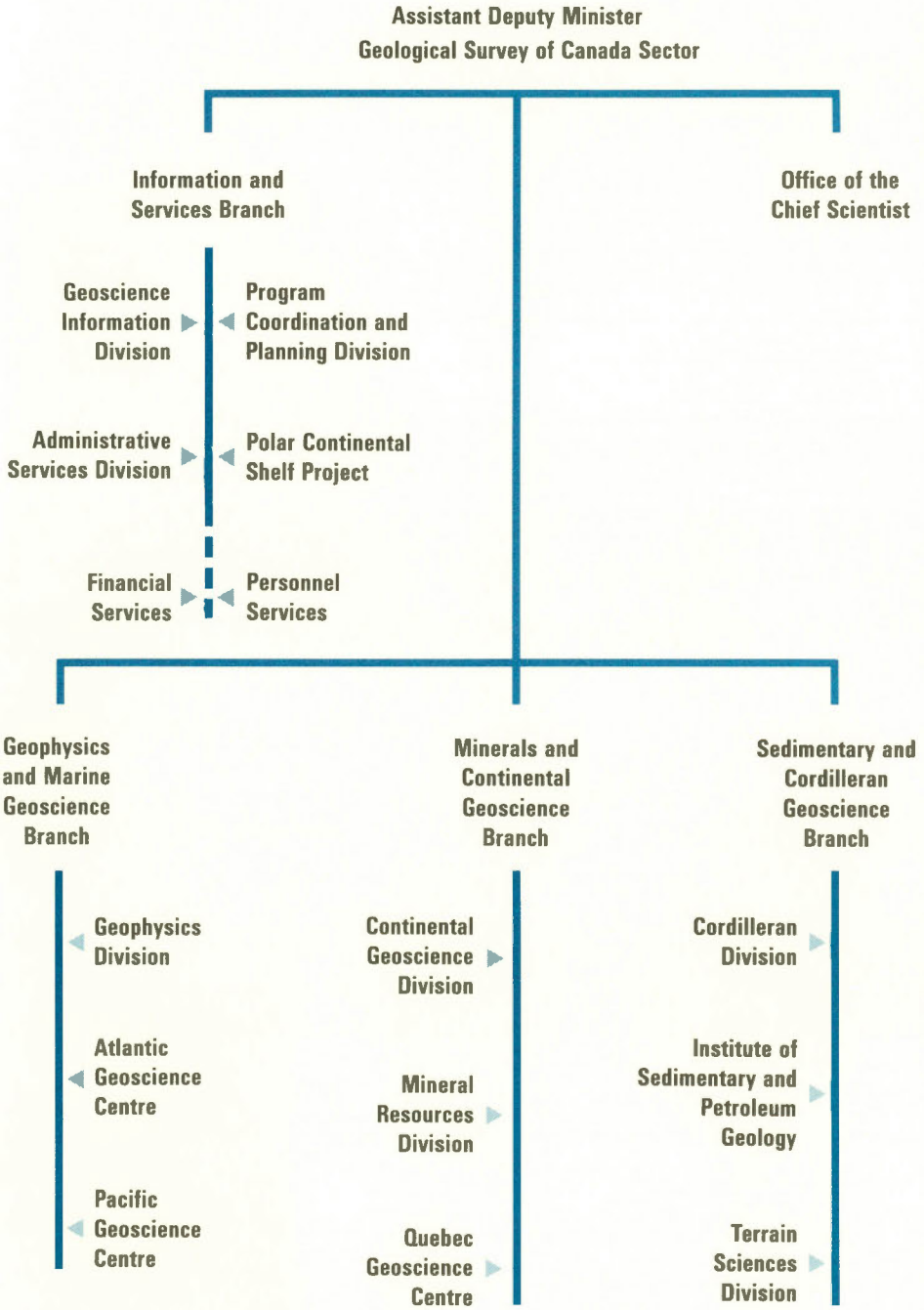
PCSP has a longstanding commitment to keeping northern communities informed of its activities and Arctic science initiatives. Shown here, students at the Qarmartalik School at Resolute, Northwest Territories, study the brand new Inuktitut version of a PCSP brochure.

"Why do I go to the north? I am beckoned to it as I am to the deep fathomless blue of the ocean, the limitless expanse of the sky, an emptiness which is so full as to exhilarate."

Photograph and journal excerpt by Marten Berkman, Arctic Awareness Program participant.

The Arctic Awareness Program provides logistics support to Canadian artists and writers who wish to work in the Arctic. Participants are selected annually by the PCSP and The Canada Council, who jointly operate the program.

Organization Chart



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Organizational Profile

As part of an ongoing review of the effectiveness of its internal organizational structure, the Survey underwent a minor reorganization in September 1989. This was in response to a number of administrative concerns expressed at all levels and was at the request of GSC Division Directors. The new organizational units are as follows:

Geophysics and Marine Geoscience Branch

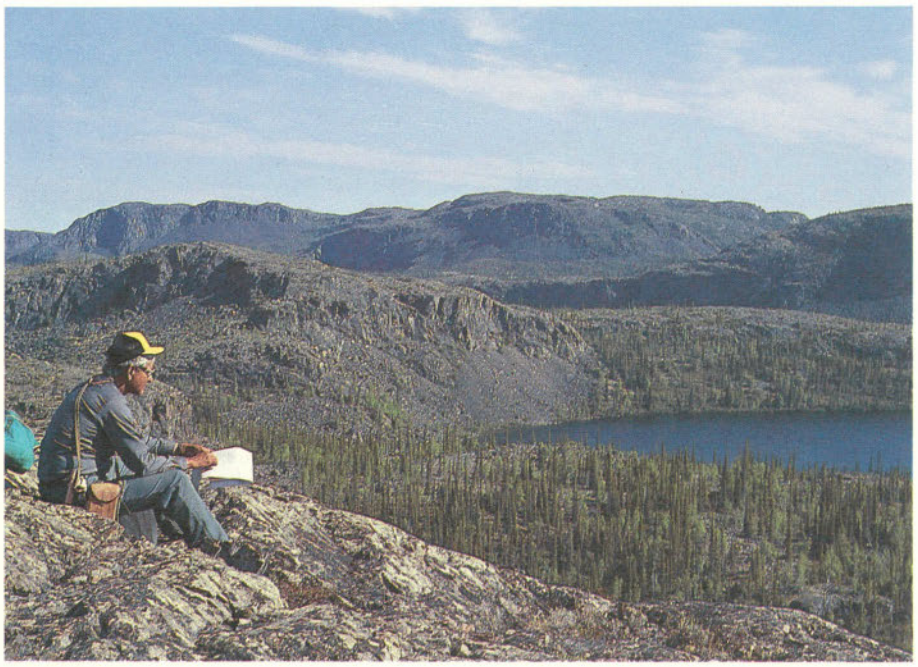
This Branch acquires, interprets and disseminates geophysical information concerning the Canadian landmass and marine geoscientific information for its coasts and offshore.

The Branch operates national observatories in seismology, geodynamics and geomagnetism and conducts national mapping programs of the earth's gravitational and magnetic fields; it sets standards for, and undertakes, contracted aeromagnetic surveys; it provides expert knowledge and information on natural hazards such as earthquakes and magnetic storms. It also carries out coastal and offshore geoscientific surveys; provides expert geological, geochemical and geophysical information on the coastal zone, seabed, offshore sedimentary basins and crustal processes; and contributes to assessments of resources, hazards and environmental quality of Canada's extensive coastal and offshore regions.

The Branch consists of the Geophysics Division in Ottawa, Ontario; the Atlantic Geoscience Centre in Dartmouth, Nova Scotia; and the Pacific Geoscience Centre in Sidney, British Columbia.

R. De Launais, GSC

Janet Drysdale and Maurice Lamontagne testing seismographic field equipment near Buckingham, Quebec.



R.T. Bell, GSC

Geological mapping: Sunil Gandhi at Great Bear Magmatic Zone, Northwest Territories.

Minerals and Continental Geoscience Branch

Through collaborative and individual project activities, the Branch contributes to the objectives of the Survey by providing a national geoscience knowledge base on Canadian mineral resources, on the geology of the Canadian Shield and Appalachian region, and on the crustal geology and deep geophysics of the Canadian landmass.

Two of the Branch's three divisions are based in Ottawa. One, the Continental Geoscience Division, conducts geological studies of the exposed Precambrian Shield and investigates, by means of geophysical studies, the geology of the Shield and its basement crustal rocks beneath the sedimentary cover. The other, the Mineral Resources Division, conducts research on mineral deposits, develops models and technology to aid in the identification and assessment of mineral resources, and operates state-of-the-art chemical and mineralogical laboratories.

The Quebec Geoscience Centre, at Sainte-Foy, Quebec, was officially opened in November 1989, as a joint venture with l'Institut national de la recherche scientifique (INRS); it focuses mainly on the geology and metallogeny of the Grenville and Appalachian geological provinces and on Quaternary studies in eastern Canada.

Sedimentary and Cordilleran Geoscience Branch

The Branch provides geoscientific information and expertise on the sedimentary basins of western and Arctic Canada, on the Cordillera, and on Canada's physical environment – the latter through the study of unconsolidated deposits and through geophysical, engineering and other studies related to terrain use and hazards.

It is responsible for undertaking bedrock geological surveys in western and Arctic Canada, for surficial geological surveys in all regions of Canada, and for coordinating oil, natural gas and coal resource assessments and frontier geoscience programs in western and Arctic Canada. It analyzes and assesses the resources of the energy-rich sedimentary basins in western and Arctic Canada, and studies geothermal energy sources in the Cordillera.

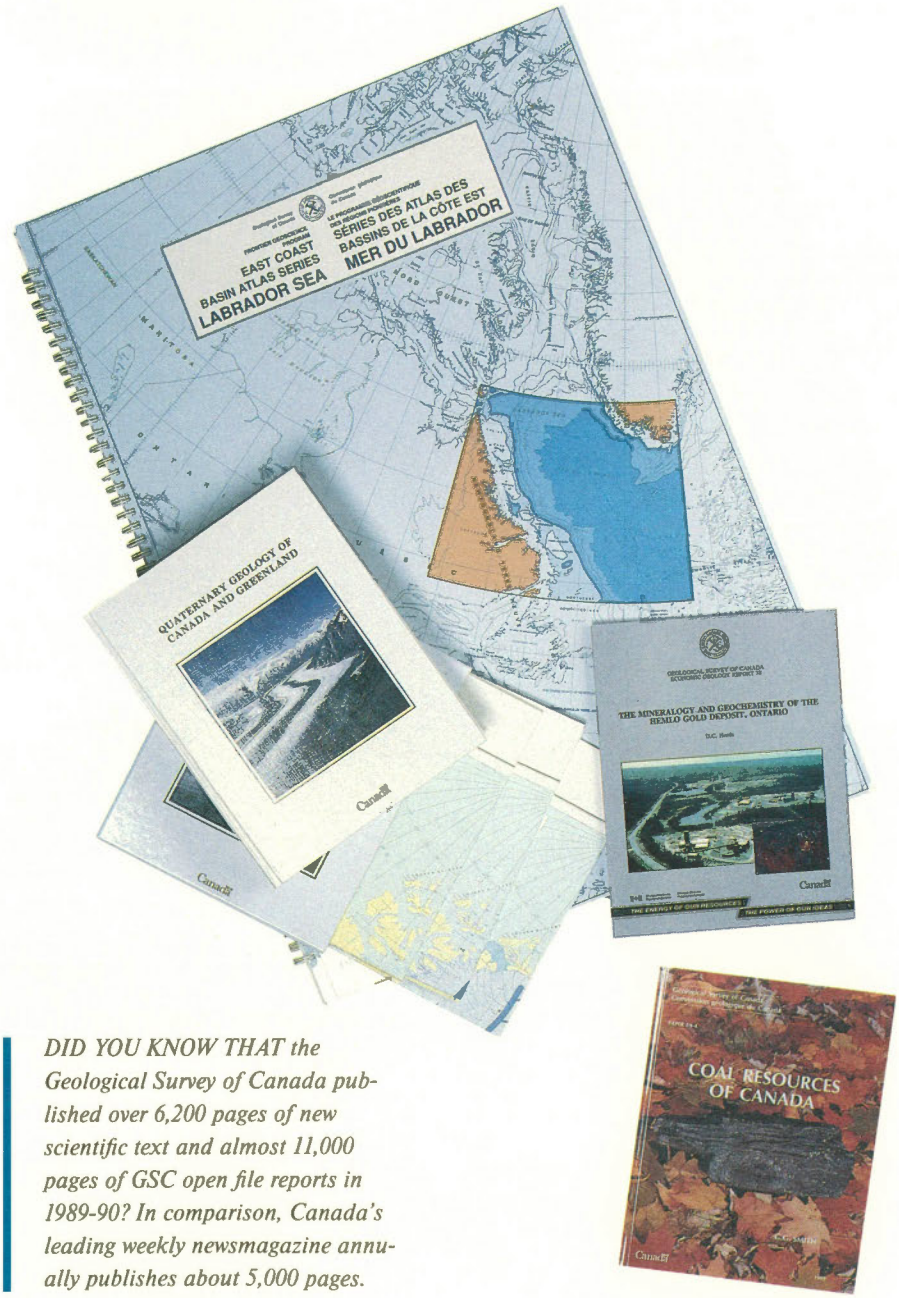
The Branch is the focal point within the Survey for research into geoscience aspects of Global Change and for international activities related to climate change. It also undertakes studies of modern geological processes, including permafrost, and landslides (particularly in the Cordillera), and environmental impact assessments of development proposals. It takes the lead on behalf of the Survey for paleontological and paleoecological studies.

B. Richards, GSC

Rocky Mountain Front Ranges, Willmore Wilderness Provincial Park, Alberta.

It has three divisions: the Ottawa-based Terrain Sciences Division; the Institute of Sedimentary and Petroleum Geology in Calgary, and the Cordilleran Division in Vancouver.

Important New Publications



◀ The **Labrador Sea Basin Atlas**, the first in a series of East Coast Basin Atlases, was published, and work on subsequent atlases proceeded: the Scotian Shelf Atlas is expected by March 1991; data for the Grand Banks Atlas should be ready for scientific review in the fall of 1990.

◀ The first volume of the *Geology of Canada* series, **Quaternary Geology of Canada and Greenland**, was released in January 1990 in both English and French. Representing the work of 63 researchers from federal and provincial governments, universities, and industry, it will stand for decades as the definitive text on the Quaternary of Canada. Work on the next two volumes—"Geology of the Eastern Margin of Canada" and "Geology of the Innuitan Orogen and Arctic Platform of Canada and Greenland"—nears completion.

◀ A comprehensive investigation of minerals present in the Hemlo gold deposits culminated with the publication **The Mineralogy and Geochemistry of the Hemlo Gold Deposit, Ontario**.

▶ A unique **Circumpolar geological map of the Arctic** (at the 1:6 million scale) was the result of collaboration between GSC scientists and their Soviet colleagues under the Canada/USSR Arctic Science Exchange Agreement (see cover illustration). A presentation copy was given to the Soviets during the Prime Minister's visit to the USSR in the fall of 1989.

DID YOU KNOW THAT the Geological Survey of Canada published over 6,200 pages of new scientific text and almost 11,000 pages of GSC open file reports in 1989-90? In comparison, Canada's leading weekly newsmagazine annually publishes about 5,000 pages.

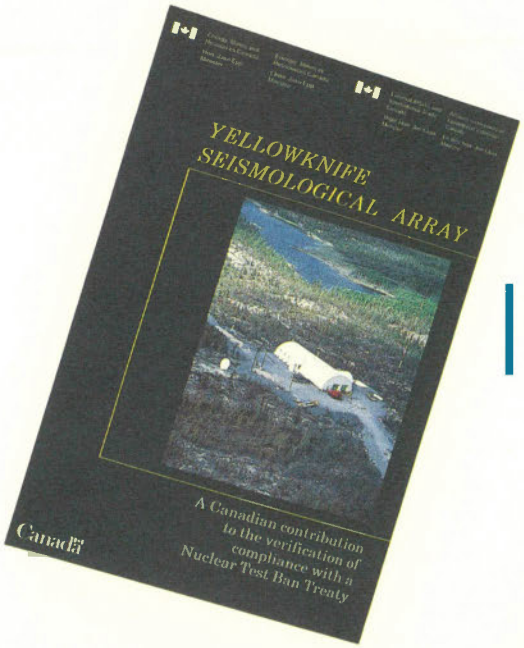
▲ **Coal Resources of Canada**, published in April 1989, was acclaimed by the Canadian coal industry as "the finest, most complete assessment of this resource ever available in Canada".

New Services, Facilities and Programs

▶ Minister Epp opened the newly refurbished **Yellowknife Seismic Array** in September 1989; the ceremony was attended by delegates from 21 countries concerned with the detection and discrimination of underground nuclear explosions. The new facility, which was the result of a three-year, $3.5 million upgrade, has already made an outstanding contribution to an international data exchange experiment which started in January 1990. Of the 30 stations worldwide which contributed data during this initial phase of the experiment, the Yellowknife Array was consistently among the top three in its capability to detect seismic events worldwide.

▶ The GSC's **Geomagnetic Activity Forecasting Service** has been upgraded to a seven-day-per-week operation to provide more timely forecasts and data for users such as Hydro-Quebec and Ontario Hydro. Geomagnetic storms disrupted power, communications and navigation systems on a number of occasions during the year.

▶ The new **Canadian Superconducting Gravimeter Installation** at Cantley, Quebec is a joint project involving seven Canadian universities and the GSC. The equipment is one of the principal tools of modern geodynamics. It will be used in the search for oscillations of the Earth's liquid core and the origin of the Earth's magnetic field, to support tidal analysis and space research (Very Long Baseline Interferometry – VLBI) and for studies of earthquake precursors. GSC provides the site and monitors the gravimeter's performance.



Booklet published by the GSC to mark the opening of the refurbished Yellowknife Seismic Array.

▶ GSC's new **Communications and Marketing Service** ensured that the results and implications of GSC's program were more widely publicized. Activities of particular note included a major GSC display at the International Geological Congress (Washington, D.C. – July 1989), the publication of a "new look" annual review of research results, and more agressive marketing of GSC publications.

Materials used by the GSC to promote its activities and to raise public awareness of geoscience.

Geology of Canada

Since its founding in 1842, the Geological Survey of Canada has from time to time published comprehensive overviews of the geology of Canada. The seventh such synthesis is now in production, and it represents a major publishing endeavour for the GSC. The *Geology of Canada*, which will consist of nine volumes and many new maps, will be the definitive reference on Canadian geology for years to come.

It also forms the Canadian contribution to the Decade of North American Geology (DNAG) Project, which commemorates the Centennial of the Geological Society of America. DNAG's goal is to present the latest knowledge about the geology and geophysics of North America, and point the way toward work to be done in future.

This ambitious project has required the dedicated effort of more than 1,000 scientists from universities, industry and the government agencies of Canada, Greenland, Mexico and the United States.

Information and Services Branch

The Survey's "product" is information, therefore, a fundamental responsibility of the Survey is making the results of its research accessible to all Canadians. Towards this end, the Branch manages all in-house publishing activities ranging from editing and cartography through to design and distribution. Other important information-related duties include maintaining the National Geoscience Library in Ottawa and managing GEOSCAN, a cooperative federal-provincial program to produce a national bibliography for the geosciences.

Program coordination and planning services are carried out on behalf of the Survey by this Branch. These have recently been expanded to include the external liaison office and the departmental research agreements program secretariat. The Branch is also responsible for all common administrative services.

The Polar Continental Shelf Project (PCSP) forms part of the Branch as well. PCSP is a unique and internationally recognized federal agency that operates a comprehensive logistics support network for science research parties working in the Canadian Arctic. It operates from bases in Resolute and Tuktoyaktuk in the Northwest Territories, and from the Canadian Ice Island Research Station in the Arctic Ocean. In keeping with its stated mandate to help maintain Canada's stewardship of its Arctic

region, PCSP plays a key role on behalf of federal agencies in increasing awareness of the Arctic amongst all Canadians.

Office of the Chief Scientist

The Chief Scientist plays an important advisory role to the Survey's senior management on the shaping of the overall scientific program so that it best addresses societal and client needs and priorities. A key responsibility over the coming months will be the development of a Long-Term Strategic Plan for the Survey to be completed by December 1990.

The Chief Scientist's Office also plays a coordinating role in broad program areas such as geophysics, environmental geoscience and Arctic research. External liaison is provided for special national and international cooperative research initiatives such as LITHOPROBE, the Ocean Drilling Program and the Canadian Continental Drilling Project.

Corporate communications and marketing strategies are planned, implemented and managed by the Office of the Chief Scientist. The objectives of these activities are to increase the profile, impact and influence of the Survey and to improve public knowledge and appreciation of the role of the geosciences in everyday life.

D. Wright, GSC

The GSC display at the International Geological Congress, July 1989, Washington, D.C.

Sector Financial Statement

Geological Survey of Canada

1989-90 Expenditures (in thousands of dollars)

	TOTAL	PERSONNEL	OPERATING	CAPITAL	GRANTS AND CONTRIBUTIONS	PERSON-YEARS
Office of the Assistant Deputy Minister	**465**	**206**	**255**	**4**	**1,900**	**4**
Information and Services Branch						
Director General	1,968	1,212	518	238	–	7
Program Coordination and Planning	700	531	134	35	–	10
Administrative Services Division	1,809	468	1,095	246	–	20
Geoscience Information Division	7,954	4,476	1,657	1,821	–	99
Total	**12,431**	**6,687**	**3,404**	**2,340**	**–**	**136**
Sedimentary and Cordilleran Geoscience Branch						
Director General	168	130	30	8	–	2
Institute of Sedimentary and Petroleum Geology	16,307	8,765	6,429	1,113	–	161
Cordilleran Division	4,181	2,456	1,421	304	–	36
Terrain Sciences Division	7,328	4,576	2,239	513	–	72
Total	**27,984**	**15,927**	**10,119**	**1,938**	**–**	**271**
Geophysics and Marine Geoscience Branch						
Director General	148	86	61	1	–	2
Atlantic Geoscience Centre	13,808	6,491	6,220	1,097	–	118
Pacific Geoscience Centre	5,370	2,027	2,482	861	–	41
Geophysics Division	12,796	6,331	4,786	1,679	–	117
Total	**32,122**	**14,935**	**13,549**	**3,638**	**–**	**278**
Minerals and Continental Geoscience Branch						
Director General	272	229	33	10	–	3
Quebec Geoscience Centre	1,368	567	551	250	–	12
Continental Geoscience Division	9,544	5,646	2,999	899	–	86
Mineral Resources Division	13,660	8,599	3,370	1,691	–	158
Mineral Development Program Office	418	116	302	0	–	2
Total	**25,262**	**15,157**	**7,255**	**2,850**	**–**	**261**
Polar Continental Shelf Project	**9,196**	**1,395**	**6,617**	**1,184**	**–**	**23**
Total Sector	**107,460**	**54,307**	**41,199**	**11,954**	**1,900**	**973**