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Energy, Mines and  
Resources Canada

Energie, Mines et  
Ressources Canada

Hon. Gerald S. Merrithew,  
Minister of State  
(Forestry and Mines)

L'Hon. Gerald S. Merrithew,  
Ministre d'Etat  
(Forêts et Mines)

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# Geological Survey of Canada

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## 1986-1987



Canada

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Outside cover: *The CSS Hudson in the Arctic in September 1986.*

Inside cover: *Wind-etched rhythmites of very fine sand and silt facies of sediment deposited in glacial Lake Bluenose (Croker River area, N.W.T.).*

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A MESSAGE FROM THE MINISTER OF STATE FOR FORESTRY AND MINES



It gives me great pleasure to introduce the first annual review of the new Geological Survey of Canada Sector.

The Minerals and Earth Sciences Program of the Department of Energy, Mines and Resources (EMR) was restructured in April 1987, when the Geological Survey of Canada was established as a separate sector within the department.

This reorganization resulted partly from the need to give the Survey a higher profile and stronger voice within EMR. Since its inception in 1842, the GSC has provided vital support to Canadian oil, gas, mineral and metal resource industries through expert advice and a comprehensive geoscientific knowledge base about the Canadian landmass and offshore regions.

The government's new Mineral and Metal Policy, which I announced at the Mineral Outlook Conference in Ottawa in May 1987, places increased emphasis on the work of the Survey: one of the linchpins of the policy is the provision of timely and accurate geoscientific information to industry and governments, labor and the general public. The policy also stresses that the Survey will "continue to work closely with provincial agencies and complement their activities in the minerals and metals field", and that its national geoscientific knowledge base will be required to serve "a variety of government policy needs, including minerals and metals programs, public safety, national security and sovereignty considerations".

We expect that the oil, gas, mineral and metal industries will continue to be the foundation of Canada's economic well-being far into the next century. And we see a strengthened Geological Survey of Canada continuing to serve their needs.

While looking forward to an exciting and challenging future, the Survey can also look back with

pride. Over the past year there have been many noteworthy accomplishments.

- In June 1986, Cabinet reconfirmed the mandate of the Polar Continental Shelf Project (PCSP) and approved an allocation of an additional \$7.5 million over a three-year period for the refurbishment of PCSP's base camps in the Arctic. Through this action we are asserting Canada's commitment to the exercise of sovereignty in our North and to a rational economic development of the region.
- In January 1987 I was delighted to join my colleague Frank Oberle, the Minister of State for Science and Technology, in announcing funding for the second phase of the Lithoprobe program, a collaborative effort involving Canadian researchers from universities, government agencies and industry. One of the largest multidisciplinary earth science studies ever undertaken in Canada, the five-year, \$25 million Lithoprobe program will keep our scientists at the forefront of worldwide deep-earth studies aimed at learning more about the interior forces that create mineral deposits.
- At meetings in Ottawa in February 1987, Canadian and Soviet delegations evaluated the three-year-old Canada-U.S.S.R. Arctic Science Exchange Program and extended it for two years. The program has successfully opened channels of communication between researchers in both countries, and we expect very exciting results over the next two years, especially in studies of gas hydrates and geological methods for identifying prospective oil and natural gas fields in the North.
- The departmental Research Agreements Program administered by this sector continued to provide funds to researchers at Canadian universities and research institutes for scientific work in support of departmental priorities: in 1986-87, \$1.4 million was awarded to 161 researchers at 40 institutions across Canada.

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Among the more gratifying experiences for me over the past year has been the growing appreciation of the role that the Survey plays in contributing to Canada's prosperity, and the recognition that is bestowed on its dedicated scientists nationally and internationally. No one brought more dedication or recognition in recent years than the Assistant Deputy Minister of Earth Sciences, the late Dr. W.W. Hutchison. His untimely and tragic death on July 3, 1987 removed from the Canadian and international scientific communities an industrious and public-spirited talent, the kind of talent that gives the Geological Survey of Canada its world-class reputation.

With deep gratitude, I dedicate this issue to Bill Hutchison.

A handwritten signature in cursive script, reading "G. Merrithew". The signature is written in dark ink and is positioned above the typed name.

Gerald S. Merrithew  
Ottawa, Canada  
June 1987

## IN MEMORIAM

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*William Watt Hutchison  
Assistant Deputy Minister, 1935-1987*

### Highlights of Bill Hutchison's Career

- |         |   |         |   |
|---------|---|---------|---|
| 1957    | - Graduated from the University of Aberdeen, U.K.   | 1980    | - Received the Royal Society of Canada's Bancroft Award for his accomplishments in international geoscience.  |
| 1962    | - Received doctorate in geology from the University of Toronto.   | 1981    | - (January) Appointed Director General of the Geological Survey of Canada.  |
| 1963    | - Joined Geological Survey of Canada and began geological mapping of the Coast Range Plutonic Complex, British Columbia.                          | 1981    | - (July) Appointed Assistant Deputy Minister, Earth Sciences Sector (now Geological Survey of Canada Sector).   |
| 1973-74 | - President, Geological Association of Canada.  | 1981-87 | - Served in numerous capacities including: member of International Council of the Ocean Drilling Program, the Advisory Board for the Centre of Earth Resources Research at Memorial University, the Scientific Committee for the Institut national de la recherche scientifique (INRS), Université du Québec and chaired the Geoscience Program under the Canada-U.S.S.R. Arctic Science Agreement. |
| 1974    | - Appointed Head of the Survey's Data System Group in Ottawa.   | 1982-86 | - President of the International Council of Scientific Unions' Committee on Storage, Automatic Processing and Retrieval of Geological Data (CODATA) for a four-year term.   |
| 1974-78 | - Director, Canadian Geological Foundation.   | 1984-87 | - Elected President of the IUGS for a five-year term.   |
| 1976    | - Seconded to the International Union of Geological Sciences (IUGS) following his appointment as the IUGS Secretary General for a four-year term. |         |   |
| 1976-78 | - Chairman, Standing Committee on International Scientific Relations, Canadian Geoscience Council.  |         |   |



## THE GEOLOGICAL SURVEY OF CANADA SECTOR

### Introduction

On April 13, 1987 the Minerals and Earth Sciences Program of the Department of Energy, Mines and Resources was substantially reorganized. The Earth Sciences Sector was divided into two new sectors: the Geological Survey of Canada Sector (GSC), the subject of this report, and the Surveys, Mapping and Remote Sensing Sector, comprising the surveying and mapping component of the former Earth Sciences Sector, and the Canada Centre for Remote Sensing.

The organizational framework of the Survey has also been restructured, but the Survey's objectives and its commitment to its clients remain the same: to ensure timely and comprehensive geological, geophysical and geochemical knowledge, technology and expertise concerning the Canadian landmass and offshore areas, including mineral and energy resources and the natural geological conditions affecting land and seabed use. These activities are required for effective exploitation of resources and land use, estimation of Canada's resource base, public safety and security, and formulation of policies.

### The New Organization

The reorganization elevated the GSC from a branch to a sector level and incorporated under this sector the Polar Continental Shelf Project (PCSP). The former divisions of the GSC were brought together under four major branches, each headed by a director general.

The **Sedimentary and Marine Geoscience Branch** comprises the Institute of Sedimentary and Petroleum Geology in Calgary, Alberta, the Atlantic Geoscience Centre in Dartmouth, N.S., and the Cordilleran and Pacific Geoscience Division with offices in Vancouver and Sidney, B.C.

The **Continental Geoscience and Mineral Resources Branch** includes the Mineral Resources, and Lithosphere and Canadian Shield divisions.

The **Geophysical Surveys, Hazards and Terrain Sciences Branch** comprises the Geophysics and Terrain Sciences divisions.

The **Program, Planning and Services Branch** includes the Office of the Chief Scientist, the Geoscience Information Division, the Program Coordination and Planning Division, Administrative Services, special programs such as the Frontier Geoscience Program, and the Mineral Development Program offices.

The sector is headed by an Assistant Deputy Minister (ADM) who provides overall management, direction and coordination to the Sector with the assistance of the **Policy and International Relations Division**, the **Financial and Personnel Services** offices and a **Francophone Coordination and Participation Office** — all located at headquarters in Ottawa. The director of PCSP and the directors general of the branches report to the ADM.

### Structure and Activities

In 1986-87 the eight divisions of the GSC were responsible for administering the mineral development agreements, the Frontier Geoscience Program, the *National Geological Atlas* Program, GSC participation in EMR research agreements and grants and contributions activities, and maintaining the national collection of paleontological type specimens. In 1986-87 the Survey had a total operating budget of about \$100 million, and a staff of about 1000 people.



*A specially designed rotary drill is deployed to recover massive sulphides from beneath the seafloor of the Juan de Fuca spreading ridge system, at water depths of 2400 m.*

**Cordilleran and Pacific Geoscience Division**, with a staff of 76 operating from offices in Vancouver and research facilities at Sidney, north of Victoria, is responsible for the availability of geological and geophysical knowledge and expertise pertaining to the mountainous regions of western Canada (British Columbia and Yukon), the Pacific Continental Margin and adjacent ocean basin. It has specific responsibility for western earthquake seismology, and geological and geophysical constraints and hazards affecting safety, security and economic development in the coastal and offshore regions.

**The Institute of Sedimentary and Petroleum Geology** in Calgary has a staff of 168. It is responsible for assessing Canada's oil, gas and coal resources, and conducting geological, geochemical and geophysical investigations pertaining to the bedrock geology, associated fossil fuels and minerals of western and northern mainland Canada, the Arctic Islands, and the western Arctic offshore.

**The Atlantic Geoscience Centre**, with a staff of 120, operates from offices and laboratories at the Bedford Institute of Oceanography, Dartmouth, N.S. It is responsible for the availability of geological and



*A Huntec Deep Tow (DTS) high resolution seismic reflection system being launched over the stern of CSS Hudson.*

geophysical knowledge and expertise relating to offshore eastern Canada, the Arctic, the contiguous ocean basins, and the Atlantic Provinces, with specific responsibilities for offshore engineering and Quaternary studies.

**Mineral Resources Division** in Ottawa has a staff of 168. This division is responsible for the availability of geological, geophysical and geochemical knowledge and expertise pertaining to the determination of the kind, distribution and origin of Canada's mineral deposits and the documentation of their geological habitats; the development and application of new methods and techniques in geochemical exploration and the conduct of regional geochemical surveys; the development and application of new methods and technologies in airborne, surface and subsurface geophysical exploration and the conduct of national and special exploration geophysical surveys; analytical chemistry, geochemistry and mineralogy and the provision of analytical services in these areas to the sector.

**Geoscience Information Division**, with a staff of 98 in Ottawa, is responsible for making the results of the Survey's scientific research program available to government, industry and the general public,



*New geophysical technologies, such as this gamma ray probe, are demonstrated to the mining industry to show that specialized borehole logging is an effective and helpful tool in mineral exploration.*

directing the largest earth sciences library in Canada, and maintaining a geoscientific information service for the benefit of the general public.

**Lithosphere and Canadian Shield Division**, with a staff of 96, is based in Ottawa. It makes available geological, geophysical and geochemical knowledge and expertise pertaining to the Canadian Shield and the deeper structure in the lithosphere underlying the remainder of Canada, and for isotope geochronology and paleomagnetism throughout Canada.

**Terrain Sciences Division**, with a staff of 93 in Ottawa, develops, implements and manages a program of systematic and topical studies of Quaternary geology, and geomorphology on a national basis exclusive of the offshore. It is responsible for geophysical surveys and technology development relating to unconsolidated deposits; engineering and associated studies relating to terrain use and hazards including the disposal of radioactive waste; the development of an understanding of the character, distribution and use of glacial and surficial materials; and the provision of geoscientific information relating to economic development and environmental impact.

**Geophysics Division**, with a staff of 118 operating from offices and research facilities in Ottawa and observation facilities throughout Canada, operates the national seismological, geomagnetic and geodynamic observatory networks. It conducts the aeromagnetic mapping program, national gravity surveys and other geophysical surveys that may be required; provides geophysical instrumentation and computing support to the sector; develops national geophysical data bases and the methodology to allow their efficient combination, manipulation and display; and studies seismicity and seismic hazards, the nature of the geomagnetic field, the stress and strain within the lithosphere and large-scale structures of the earth.

## Highlights

### GEOSCIENCE KNOWLEDGE BASE

- A cooperative program in the Dawson, Yukon area, involving scientists from the GSC and the Department of Indian and Northern Affairs, showed that large thrust faults have an overlap of more than 100 km and that some of these bring together contrasting facies, not distinct terranes. The new geological information

obtained for this area will result in better appraisals of mineral and hydrocarbon potential for the northern Yukon.

- A three-year project of mapping the Quaternary geology of Prince of Wales Island, N.W.T., was completed. The abundance of fossil whale bones of different ages was found to vary on the numerous raised beaches that characterize the area. Field parties discovered fossils of 44 bowhead whales, 13 narwhal, and one walrus, as well as 46 driftwood and 17 marine shell specimens. Two theories have been proposed: variations reflect changes in sea ice conditions during the postglacial period, and the postglacial emergence occurred as uplift of a horizontal block.
- The GSC Radiocarbon Dating Laboratory, now in its twenty-seventh year, has dated more than 4300 samples. The dates are used to establish, for example, correlation of strata and ages of archeological material. These data are now accessible through a computer data base.
- Recent studies suggest that the Canadian ice caps may have melted completely and only a small remnant of the Greenland ice sheet may have survived during the last interglacial. The worldwide rise in sea level then was only 6 m and this new evidence of major melting in the Northern Hemisphere strongly suggests that the size of the West Antarctic ice sheet has been stable



A major fossil discovery was made during the three-year mapping program of the Quaternary geology of Prince of Wales Island, N.W.T. Shown here is the nasal bone of a bowhead whale found at 62 m above sea level.

for a long time. Sea levels would have been higher if melting had occurred in Antarctica.

- Aeromagnetic surveys funded by the Frontier Geoscience Program have obtained data in recent years from the Grand Banks and northeast Newfoundland margin. The data have been integrated with deep seismic reflection and new refraction seismic data to map the ocean-continent transition along the Grand Banks margin and the sedimentary basins and deep structures between Newfoundland and Nova Scotia. These studies will give a better understanding of the development of the area and contribute directly to hydrocarbon resource potential assessments.
- Basin atlas compilation for the Labrador Sea, Grand Banks, Scotian Shelf and Gulf of St. Lawrence areas proceeded rapidly. Work on the *Labrador Atlas* was greatly assisted by the compiled data bases made available by Petro-Canada and BP. The basin atlas concept is being used to present all Frontier Geoscience Program results.
- A new model for the origin of quartz-rich sandstones suggests that supercontinents develop at recurring geological intervals of 300 Ma (million years) resulting in low sea levels, arid climates and glaciation with associated eolian sandstones, associated evaporites and sedimentary copper deposits. Subsequent break-up of the land masses causes widespread warm-wet climates and major marine transgressions producing marine sandstones rich in weathered granitic debris. Such rocks contain ironstone, petroleum, phosphate, bauxite, manganese and lead-zinc deposits.
- A major electromagnetic induction survey was conducted across the Kapuskasing Structural Zone, an upthrust section of old Archean crust. This exposure offers a unique opportunity to examine very deep crustal structure and to develop an understanding of the processes that formed the rocks and their ore deposits.
- In 1986 a joint GSC-U.S. Geological Survey project to study the crustal evolution of the Great Lakes Basin began. Deep seismic reflection and refraction data are being used to resolve the structure of the deep crust. The imaging of the Grenville Front at depth beneath the western end of Georgian Bay shows spectacular series of southeast-dipping reflections interpreted as zones of intense ductile shear. A band of subhorizontal reflections at a depth of 33 to 40 km may delineate the base of the crust beneath the Grenville Province.



Overburden drilling, Chaudière River valley, Quebec.

- Several Frontier Geoscience Program projects involving geodynamic basin modeling contributed to the evaluation of hydrocarbon potential in various sedimentary basins. The first phase of a tectonic subsidence and basin evolution model for the Sverdrup Basin was completed. This involved a new quantitative subsidence model, which couples data concerning the thermal evolution of the lithosphere and overlying sediments and incorporates information about regional isostatic compensation.
- The Canadian contribution — data compilation — to the *Magnetic Anomaly Map of North America* has been completed and color separations delivered to the U.S. Geological Survey for printing and publishing at a scale of 1:5 million. This first magnetic anomaly map of an entire continent required considerable skill in editing, amalgamating, leveling and projection transformation of data from diverse sources.

#### ENERGY AND MINERAL RESOURCES

- The value of fossil conodonts as indicators of hydrocarbons continues to be demonstrated with funding from the Frontier Geoscience Program. Triassic conodonts from the Queen Charlotte Islands have provided not only critical biostratigraphic information but, by means of their Colour Alteration Index, paleotemperature data that are critical in assessing these hydrocarbon source beds.
- Mesozoic strata in the Laberge and Whitehorse areas of the Yukon were identified as including likely source rocks for hydrocarbons as well as

reservoir rocks and structural traps that are near the optimum for hydrocarbon generation.

- The stratigraphic succession identified in northern Bowser Basin, B.C. was traced southward to the Klappan anthracite deposits. The model derived from this new information will help in delineating areas of additional anthracite deposits.
- Studies of rank and composition of anthracite coals of the Kayak Formation in northern Yukon indicate a potential source for high-quality thermal coal. However, the high coal rank also suggests that in this area rocks of Mississippian age or older may not be good oil prospects, although some may be potential gas sources. High-quality lignitic to subbituminous thermal prospective coal sources were also identified in the Fort Norman area, District of Mackenzie.
- About 80 km<sup>2</sup> of titaniferous sands that may be several metres thick were mapped in Queen Charlotte Sound off the coast of British Columbia. Their economic potential requires further study.
- Off the west coast, an integrated geophysical-geological seafloor study was completed in the rift valley of the northern Juan de Fuca Ridge, the site of sediment-hosted sulphide deposits. Some 500 heat-flow measurements assist in defining the regional pattern of hydrothermal circulation. Two active discharge sites are clearly reflected in the surface heat-flow. The sulphide outcrops were mapped with video and still cameras. Other bottom photography revealed active high-temperature 'black-smoker' vents at one site. Some success was obtained using a bottom-powered rock drill on two sulphide deposits.
- Surficial mapping in the Cariboo district of British Columbia disclosed a buried valley that could host a placer gold deposit. The information was published in GSC's *Current Research* in January 1987 and resulted in the staking of the site.
- Regional Quaternary surveys and drift geochemical studies reported in 1983 and 1985 identified anomalously high arsenic and gold values in overburden sediments about 40 km northeast of Churchill, Manitoba. Subsequent detailed work in 1986 by the Manitoba Department of Mines and Energy defined a glacial dispersal train with very high gold values. It has been traced to gold-bearing source rocks attractive for mineral exploration.
- Research on the use of remote sensing in mineral exploration now includes joint projects with

industry. Landsat images are providing promising results in identifying bedrock lineaments related to mineralized zones in northern Saskatchewan. The possibility of using Landsat data to monitor vegetation stress related to debris from ultramafic rocks is being studied in the asbestos belt in the Thetford Mines area of Quebec. Image processing and analysis methods were used to integrate Landsat data, digitized geological information, catchment basin geochemistry and other parameters to predict tungsten skarn mineralization associated with buried intrusions in the Nahanni area of the Yukon.

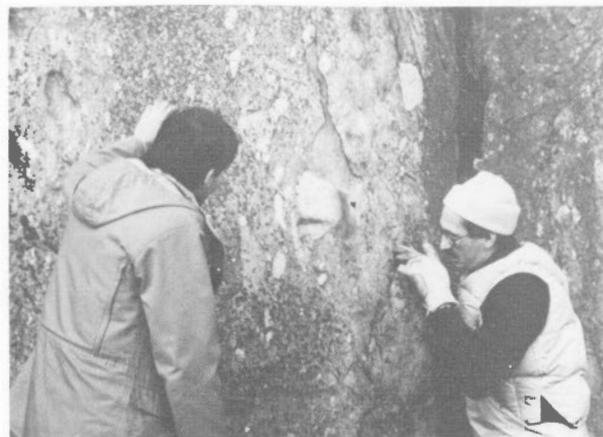
- A previously unmapped ultramafic body near Osik Lake, Manitoba was found by applying drift prospecting techniques. Samples contain significant amounts of nickel and chromium and are being analyzed for gold and platinum group elements.
- The mineral industry focused on platinum group elements (PGE) and gold in 1986, and GSC's Mineral Resources Division completed preliminary field investigations of about 50 mafic-ultramafic intrusions with PGE potential. Significantly, the previously unrecognized relationship between selenium and sulphur ratios in magmatic sulphides can be used to target intrusions favorable to PGE concentration.
- Under various mineral development agreements, approximately 152 000 km<sup>2</sup> have been covered

by geochemical surveys and 13 100 samples collected. Since 1973 geochemical surveys have covered 1.8 million km<sup>2</sup> throughout Canada, providing summary information for lake and stream sediments, ground and surface waters and heavy mineral concentrates. A recent heavy mineral survey in Gaspésie resulted in extensive staking.

- Biogeochemical test surveys by GSC in the La Ronge belt of Saskatchewan outlined anomalous gold zones that led industry to new discoveries. Geochemical investigations of the Bennet Lake Caldera Complex on the B.C.-Yukon border and of the Whitehorse Trough indicate potential for precious metal mineralization. Near Atlin, B.C. similar studies suggest a 'motherlode' environment comparable to the California occurrences.
- To assist Canada's mineral exploration industry, the 1:5 million *Radioactivity Map of Canada* was published, as well as 278 radio-element and VLF-EM maps. A major joint-venture demonstration of borehole geophysics was conducted in British Columbia with the participation of seven mining companies.
- In association with the Alberta and British Columbia geological surveys, GSC was host to the highly successful Western Canada Coal Geoscience Forum, which helped to promote the transfer of GSC-developed coal geoscience technologies. About 150 geoscientists attended.
- The hydrocarbon potential of the Western Canada Basin is being investigated. A regional petroleum geology study of the Peace River Formation integrating outcrop and subsurface



The study and logging of diamond-drill core is essential to assessing mineral resources under various federal-provincial mineral development agreements.



A drill site in a brecciated zone, Val-d'Or district, Quebec, is examined in order to characterize background values of gold.

data involves subsurface mapping, facies analyses, geochemistry, source-rock analysis and paleontology. A study to define the nature and timing of the deformation associated with the Sweetgrass Arch in southern Alberta emphasizes the use of existing geophysical and geochemical data that can be related to the petroleum geology of the Peace River Arch. A collaborative project with the Alberta Geological Survey will study the Peace River Arch in 1987.

- Petroleum resource estimates and reports were prepared for three disputed boundary areas: Canada-Alaska, and Canada-U.S. boundaries in Dixon Entrance and Juan de Fuca Strait. Background information for these estimates is provided by special programs such as the Frontier Geoscience Program and the Boundary Disputes Program. GSC staff also participated in a review of an economic analysis of the remaining conventional oil resources of western Canada.
- Studies in the Sheldon Lake area of the Yukon showed that certain stratigraphic markers can be traced across the entire Selwyn Basin, providing

better control for the search for mineralized strata. Potential gold targets were identified in this area and in the Carmacks area.

#### ENVIRONMENT AND HAZARDS

- Following a magnitude 6.6 earthquake in the Nahanni region, N.W.T. in October 1985, three accelerographs were installed to record aftershocks in the Mackenzie Mountains, and on December 23, 1985 they recorded a shallow (6 km deep) earthquake of magnitude 6.9. Processing and analysis of the strong-motion accelerograph data have defined the largest earthquake ground motion ever recorded – the acceleration exceeded twice that of gravity. The earthquake triggered an avalanche of 5 million to 7 million cubic metres of massively bedded limestone, the fourth largest landslide in Canada in this century. The Nahanni results are considered typical of seismic ground motion that would result from a large earthquake in eastern Canada and are relevant to building and



*During the year, GSC scientists continued to monitor the aftereffects of the magnitude 6.9 earthquake in the Nahanni region of the Yukon, December 23, 1985.*



The massive rock avalanche triggered by the Nahanni earthquake consisted of 5 million to 7 million cubic metres of limestone, making it the fourth-largest Canadian landslide in this century. Note the initial rupture surface (R), the 30-50 m high lateral scarp (L), the large blocks in the debris (B) and the mobile tongue (T).

engineering design codes. Nahanni sites were reoccupied for further analysis of aftershock distribution in 1986. Eleven months after the first earthquake, 300 events up to magnitude 4.5 were recorded within two weeks.

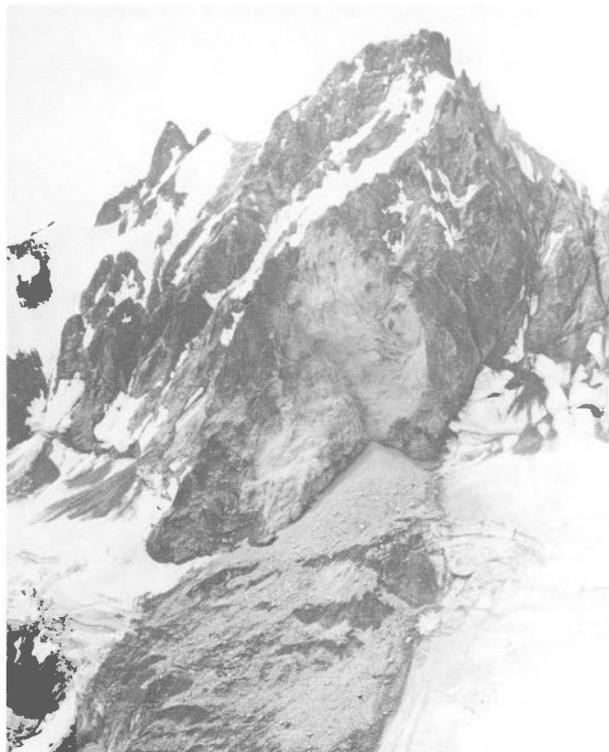
- Treasury Board approval was received in July 1986 for a major upgrade of the Yellowknife Seismic Array, the major Canadian seismograph station contributing data to monitor a global comprehensive nuclear test ban. Progress in 1986-87 included preparation of comprehensive system- and software-design documents, construction of four broad-band seismometer vaults, acquisition of state-of-the-art, broad-band and short-period seismometers, radio-transmission and receiving hardware and computer systems for data acquisition. Contracts for a new centre of operations building and for software design have been awarded. The facility, which will



The Canada-U.S.S.R. Arctic Science Exchange Agreement, signed in 1984, was extended for another two years following negotiations held in Ottawa in February 1987. The late Dr. W.W. Hutchison (right), Assistant Deputy Minister, and Dr. I.S. Gramberg of the U.S.S.R. Ministry of Geology, co-chaired the geoscience component of the program.

ultimately comprise 32 broad-band and short-period seismometers, will provide a design model that may interest other countries.

- The rock properties studies in support of AECL's Nuclear Fuel Waste Management Program have concluded with the compilation of Level II Concept Assessment Documents for the Underground Research Laboratory, Atikokan and East Bull Lake research areas. During its eight years the program advanced and developed automation of modal analyses of core samples, techniques for identification and characterization of microcracks that could influence radionuclide migration, and the experimental production and detection of thermally induced microcracks.
- A joint research program including Canadian, American and Chinese scientists used two Chinese vessels to gather sedimentological and geotechnical data in the Bohai Sea. The data will be useful in assessing seafloor hazards in the Beaufort Sea off the Mackenzie Delta, where ice cover makes similar data difficult to acquire.
- A major study of landslide hazards in the southern Cordilleran region continued. Fieldwork concentrated on the avalanche triggered by the 1985 Nahanni earthquake; the Mount Caley area, where recent mapping has disclosed a massive landslide in the past that blocked the Squamish River; Mount Meager, where a large



*Rock avalanche, Mount Meager, B.C.*

rock avalanche occurred in the spring of 1986; the Mount Currie area, where the massive toppling of the northeast ridge was discovered; and various investigations done for B.C. Hydro on slope stability above several reservoirs and dams.

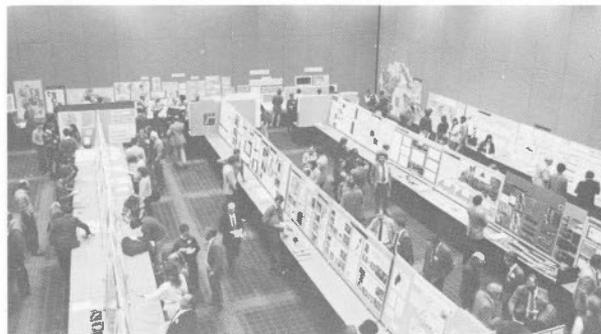
- Terrain conditions and terrain performance in permafrost environments were investigated. Studies continued along the right-of-way of the pipeline from Norman Wells to Zama Lake. In the Mackenzie Delta - Tuktoyaktuk area studies of the growth of permafrost in drained lakes and the growth of pingos continued. A 1:1 million map of permafrost and ground ice conditions in northern Yukon and northwest District of Mackenzie is being compiled.
- More than 3000 seabottom seismic refraction records were obtained using the Canadian Coast Guard vessel, the *Nahidik*, in the Beaufort Sea. These data are being used to map ice-bonded

permafrost. Other studies in the delta area concerned sediment transport and cliff and beach profile measurements.

- A research laboratory established to study physical properties and stress history of the seabed will aid in assessing constraints and hazards that may affect offshore development.

#### GENERAL

- A new X-ray fluorescence spectrometer and new automated equipment for rapid determination of sulphur and water were acquired. Research continued on new methods of sample vaporization in inductively coupled mass spectrometry, evaluation of microwave digestion of samples and techniques for determining gold and platinum-group elements in dry and ashed vegetation.
- A second solid-source mass spectrometer installed in the Geochronology Section has increased capacity and flexibility. Various improvements in U-Pb zircon analysis procedures doubled production during the year. Analyses were carried out for many GSC divisional projects.
- GSC participated in a six-day workshop on petroleum resource assessments in Malaysia. Participants attended from 11 East Asian countries.
- The two-day Current Activities Forum held in Ottawa was attended by more than 800 industry, university and other geoscientists. Staff of the Cordilleran and Pacific Geoscience Division



*The annual Current Activities Forum held in Ottawa, January 20-21, 1987 gave GSC scientists the opportunity to discuss the results of their research with more than 800 registrants from industry, universities and other government agencies.*

were actively involved in the Cordilleran Round-up sponsored by the B.C. and Yukon Chamber of Mines.

- In Ottawa in October 1986, at the request of External Affairs, GSC was host to an international meeting of telecommunications experts from about 20 countries to discuss ways of distributing seismological data among countries participating in the United Nations Committee on Disarmament. Such data would play a major role in verifying compliance with the provisions of a comprehensive test ban treaty, an objective of Canada's foreign policy. The Secretary of State for External Affairs, The Right Honourable Joe Clark, and the Minister of State for Forestry and Mines, The Honourable Gerald Merrithew, participated.
- A very successful workshop on magnetic observatory instruments, sponsored by the International Association of Geomagnetism and Aeronomy (IAGA), was held in Ottawa in August 1986. Forty-one participants from 17 countries observed and compared operating observatory instruments.
- The initial field testing of the absolute gravity meter was successful. In an international comparison at the Joint Institute for Laboratory Astrophysics, Boulder, Colorado, the Canadian and U.S. instruments of similar design recorded absolute values within 25 micro-Gal of one another. Subsequently, as a prelude to a planned national network, an absolute gravity site was established at Calgary. A network of absolute gravity sites was established in the Ottawa area using D-meters to monitor their suitability.
- Dozens of upright 40-million-year-old fossilized wood stumps in growth position, located at several places on Ellesmere and Axel Heiberg islands attracted considerable media attention as a result of work conducted in the summer of 1986 by GSC and Canadian university researchers. The 'fossil forests' have been known for

100 years, and their locations were pinpointed during GSC's 1955 geological mapping campaign, Operation Franklin.



*Stumps and logs of the Paleocene 'fossil forest' on Ellesmere Island, N.W.T.*

**For further information:**

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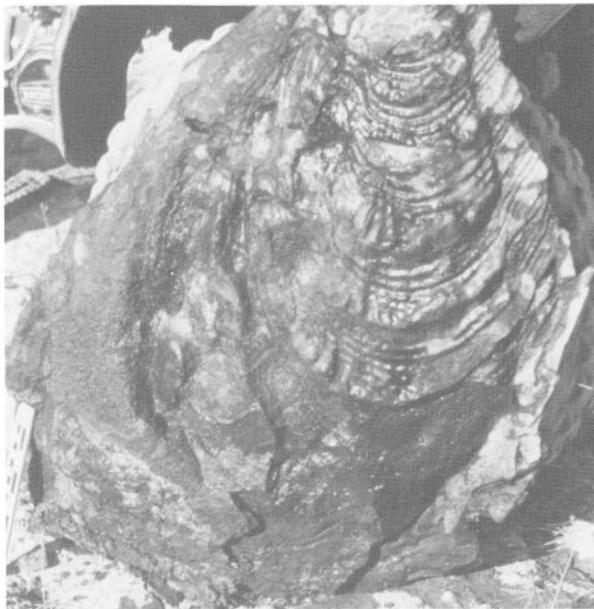
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## THE POLAR CONTINENTAL SHELF PROJECT, 1986-87

The Polar Continental Shelf Project (PCSP) coordinates studies of scientific problems unique to the Canadian Arctic and provides vital logistics support and advice to scientific research groups working in the Arctic Islands and the Arctic Ocean. PCSP works closely with other branches of Energy, Mines and Resources Canada in planning and carrying out an integrated scientific program in the Arctic. It also cooperates with other government departments and agencies and with universities in providing expertise and facilities for their studies, and keeps both the scientific community and Arctic residents informed of ongoing scientific operations. PCSP's multidisciplinary, interdepartmental, interagency character continues to be instrumental in fostering effective and economical scientific development of the Canadian Arctic.

PCSP maintains base camps at Tuktoyaktuk in the Mackenzie Delta and at Resolute on Cornwallis Island, which coordinate fieldwork, generally carried out between mid-February and late September. Headquarters in Ottawa provides management direction and the necessary administrative support to activities.



*The discovery of a large freshwater clamshell in the Kanguk Formation in central Ellesmere Island added valuable insight to the history of this region. An all-terrain vehicle (ATV) provides the scale.*

### Highlights

- In June 1986, Cabinet reconfirmed PCSP's mandate and allocated funds (totaling \$7.5 million over three years starting in fiscal year 1987-88) for the refurbishment of PCSP's base camps at Resolute and Tuktoyaktuk.
- Major GSC geological and geophysical studies on northern Melville Peninsula, Grinnell Peninsula of Devon Island, northern Boothia Peninsula and the Sverdrup Basin were supported by PCSP. The geological projects are part of an ongoing mapping program in the Canadian Arctic, and the geophysical project in the Sverdrup Basin was to determine what kind of Quaternary sediments lie beneath the interisland channels.
- The annual bathymetry-gravity survey in March and April in Committee Bay - Gulf of Boothia area used a Siledus Navigation System to locate data points. Water depths were taken every 2 km and gravity data every 6 km. Logistical support was also provided to the vessel *John P. Tully* to complete its detailed hydrographic



*A laboratory technician at the Arctic Research Establishment, Pond Inlet, conducts salinity and conductivity tests on water samples as part of an oceanographic study of Eclipse Sound.*



*Native survey trainees from Pond Inlet take part in an interdepartmental oceanographic and ice physics investigation of Eclipse Sound.*

- sounding for the definition of shipping lanes in the Beaufort Sea.
- Interest in the Beaufort Sea area remains high. PCSP supported studies by various agencies to investigate such disparate subjects as ground ice, shorebirds, coastal processes, physical and chemical oceanography, ice pressure ridges and marine biology.
- Wildlife studies by federal and territorial scientists and wildlife officers continue to receive major support from PCSP. The habitat population and migratory habits of marine mammals, migratory birds, caribou and muskox have been studied for several years.
- Some 55 separate university parties were supported in 1986; of these, 11 were from foreign universities and the remainder were Canadian.



*Geophysical techniques are applied to locating artifacts: in this case, the surveying instruments reportedly buried by Captain M'Clure at Victory Harbour, Boothia Peninsula in the 1850s during his expedition to locate the North Magnetic Pole.*

- The base camp facility on the Ice Island in the Arctic Ocean was in use from March 2 to October 12, 1986. Geological, geophysical and oceanographic investigations of the continental shelf north of Axel Heiberg Island were conducted. The island, which was moving irregularly, was continuously tracked.

**For further information:**

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**GEOLOGICAL SURVEY OF CANADA SECTOR FINANCIAL STATEMENT**  
**1986-87 Expenditures (in thousands of dollars)**

|   | TOTAL          | PERSONNEL     | OPERATING     | CAPITAL      | GRANTS AND<br>CONTRIBUTIONS | PERSON-<br>YEARS |
|---|----------------|---------------|---------------|--------------|-----------------------------|------------------|
| <b>SEDIMENTARY AND MARINE GEOSCIENCE</b>                        |                |               |               |              |                             |                  |
| Cordilleran and Pacific Geoscience                              | 7 754          | 3 713         | 3 080         | 961          | -                           | 76               |
| Sedimentary and Petroleum Geology                               | 15 628         | 7 016         | 7 236         | 1 376        | -                           | 168              |
| Atlantic Geoscience Centre                                      | 15 260         | 5 622         | 8 268         | 1 370        | -                           | 120              |
|   | <u>38 642</u>  | <u>16 351</u> | <u>18 584</u> | <u>3 707</u> | <u>-</u>                    | <u>364</u>       |
| <b>CONTINENTAL GEOSCIENCE AND MINERAL RESOURCES</b>             |                |               |               |              |                             |                  |
| Mineral Resources   | 14 788         | 7 717         | 6 362         | 709          | -                           | 168              |
| Lithosphere and Canadian Shield                                 | 9 707          | 5 296         | 4 239         | 172          | -                           | 96               |
|   | <u>24 495</u>  | <u>13 013</u> | <u>10 601</u> | <u>881</u>   | <u>-</u>                    | <u>264</u>       |
| <b>GEOPHYSICAL SURVEYS, HAZARD AND TERRAIN SCIENCES</b>         |                |               |               |              |                             |                  |
| Geophysics  | 14 708         | 5 716         | 6 718         | 2 274        | -                           | 118              |
| Terrain Sciences  | 9 685          | 4 605         | 4 731         | 349          | -                           | 93               |
|   | <u>24 393</u>  | <u>10 321</u> | <u>11 449</u> | <u>2 623</u> | <u>-</u>                    | <u>211</u>       |
| <b>PROGRAMS, PLANNING AND SERVICES</b>                          |                |               |               |              |                             |                  |
| Geoscience Information  | 4 730          | 3 358         | 1 278         | 94           | -                           | 98               |
| Planning, Common Services and<br>Special Projects               | 5 882          | 2 235         | 3 104         | 543          | -                           | 54               |
|   | <u>10 612</u>  | <u>5 593</u>  | <u>4 382</u>  | <u>637</u>   | <u>-</u>                    | <u>152</u>       |
| <b>POLAR CONTINENTAL SHELF PROJECT</b>                          | <u>6 723</u>   | <u>942</u>    | <u>5 070</u>  | <u>711</u>   | <u>-</u>                    | <u>21</u>        |
| <b>PROGRAM MANAGEMENT AND SUPPORT<br/>(SECTOR HEADQUARTERS)</b> | <u>5 445</u>   | <u>640</u>    | <u>185</u>    | <u>15</u>    | <u>4 605</u>                | <u>13</u>        |
| <b>TOTAL - SECTOR</b>   | <u>110 310</u> | <u>46 860</u> | <u>50 271</u> | <u>8 574</u> | <u>4 605</u>                | <u>1 025</u>     |

GEOLOGICAL SURVEY OF CANADA  
SECTOR  
ASSISTANT DEPUTY MINISTER  
SOUS-MINISTRE ADJOINT  
SECTEUR DE LA  
COMMISSION GÉOLOGIQUE DU CANADA

Chief Scientist  
Programs, Planning and Services Branch  
Scientifique principal  
Direction des programmes,  
de la planification et des services

Policy and International Relations  
Politiques et Relations internationales

Polar Continental Shelf Project  
Étude du plateau continental polaire

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Participation Office  
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Services financiers

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Division des services administratifs

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Projets spéciaux

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Programme géoscientifique des  
régions pionnières

Mineral Development Program Office  
Bureau du programme  
d'exploitation minière

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Mineral Resources Branch  
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Terrain Sciences Branch  
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des risques naturels et de  
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Atlantic Geoscience Centre  
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