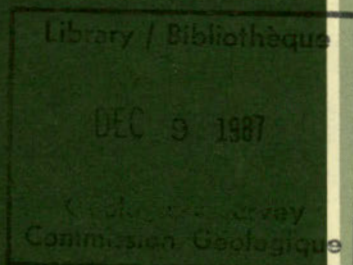


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*Geological Survey of Canada
and the former
Earth Physics Branch*



**ANNUAL REVIEW
1985-1986**

RENCE/RÉFERENCE

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

Canada

1986



Energy, Mines and
Resources Canada

Énergie, Mines et
Ressources Canada

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

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



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GEOLOGICAL SURVEY OF CANADA

The objective of the Geological Survey of Canada (GSC) is to ensure 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 amalgamation of the Earth Physics Branch and the Geological Survey was announced in January 1986 and took effect on April 1. Most programs of the GSC and the Earth Physics Branch are continuing as before. Prior to reorganization, the Geological Survey comprised eight divisions and the Earth Physics Branch three. The reorganized Geological Survey has eight divisions (see organization chart, page 8): Atlantic Geoscience Centre, Geophysics, Geoscience Information, Lithosphere and Canadian Shield, Mineral Resources, Terrain Sciences, Institute of Sedimentary and Petroleum Geology, and Cordilleran and Pacific Margin. These divisions will be reflected in the 1986-87 review.

Among major achievements in 1985-86, a comprehensive reassessment of the undiscovered oil resources of the Western Canada Sedimentary Basin was completed, and a large sediment-hosted sulphide deposit was discovered on the ocean floor off Canada's west coast, the first comparable to mineral deposits mined on land. Off Canada's east coast, staff completed deep seismic transects and geological interpretations of the data acquired. A major aeromagnetic survey off Newfoundland was carried out in cooperation with a consortium of petroleum companies. The first season of geological and geophysical investigations coordinated by the Polar Continental Shelf Project from the floating ice island in the Arctic Ocean northwest of the Arctic Archipelago was successfully completed and plans made for further work in 1986. Staff cooperated with university and industry in a deep seismic survey of the Peace River Arch area in northern Alberta. Canada became a full participant in the Ocean Drilling Program and took part in several successful cruises, including one in the Labrador Sea - Baffin Bay area.

Organization

The eight divisions of the GSC in 1985-86 were coordinated through headquarters.

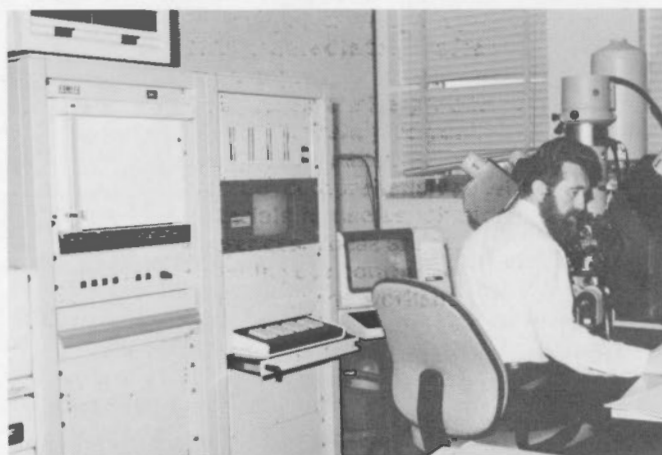
Cordilleran Geology Division, with offices in Vancouver and at the Pacific Geoscience Centre, Sidney, B.C., studies the geology of the Cordilleran

region and the adjacent Pacific continental shelf and margin. Results are used to assess mineral and hydrocarbon potential and aid in land use and environmental protection.

Institute of Sedimentary and Petroleum Geology, Calgary, collects information on the sedimentary basins of western and northern mainland Canada and the Arctic - regions which contain much of our oil, natural gas and coal resources. It prepares estimates of Canadian potential oil and gas resources in cooperation with other federal agencies, and maintains a repository of samples, cores and other data derived from work of the petroleum industry on Canada Lands.

The Atlantic Geoscience Centre, Dartmouth, N.S., studies the geology, geophysics and geochemistry of the Atlantic and Arctic offshore areas, obtaining data used in the search for hydrocarbon resources, in resource evaluations, in the protection of the marine environment, and in improving the safety of coastal and offshore engineering structures.

Economic Geology and Mineralogy Division conducts geological studies of metallic and other mineral deposits to determine their distribution, origin and potential abundance, thereby facilitating resource exploration and policy formulation. The division analyzes rocks, minerals and ores for the other GSC divisions.



This image analyzer is capable of quantifying geometric and densitometric information. When used in conjunction with the scanning electron microscope and X-ray microanalyzer, it can also quantify the chemical composition of the sample.

Geological Information Division communicates the results of the scientific programs by preparing and publishing maps and reports, maintains Canada's largest earth science library, and provides a public information system.

Precambrian Geology Division studies the bed-rock geology of the mineral-rich Precambrian Shield to provide data used by industry in the search for mineral deposits and by government in developing mineral policies. The division provides isotopic age and paleomagnetic determinations and petrological information for all parts of Canada.

Resource Geophysics and Geochemistry Division is a national centre for research and development into geophysical and geochemical methods used in geological interpretation and mineral exploration, and it conducts systematic geophysical and geochemical surveys. Technologies developed are tested and made available to the private sector as well as to government.

Terrain Sciences Division studies the geology of the unconsolidated materials of the landmass, processes that modify the landscape, and hazards that may affect land use. It coordinates studies on nuclear fuel waste management.

Headquarters in Ottawa provides senior management direction and administrative support services, and coordinates branchwide activities such as the Frontier Geoscience Program, the Mineral Development Agreements Program, grants programs and international relations.

1984-85 Highlights

GEOSCIENCE KNOWLEDGE BASE

- ISPG scientists coordinated a major crustal seismic refraction survey in the Peace River Arch area, which employed personnel and equipment from six universities and the Earth Physics Branch. This is a comprehensive study and appraisal of the geology, geochemistry and geophysics of the area to discover how intrabasinal arches and troughs, structures that have obvious importance for petroleum exploration, were formed.
- As part of a long-term study of the surficial geology of the Fraser River basin, stratigraphic data were collected from extensive exposures along the river and detailed sedimentological

studies made of lake sediments that underlie tills in the Quesnel area.

- Scientists from the GSC and Nordic and Canadian universities continued to study the glacial history of east-central Ellesmere Island and western Greenland. Related studies include fluctuations in sea level, botany and climatic changes.
- In the northwestern Shield field studies focused on the boundary between Slave and Churchill provinces. The southern part of the boundary is defined by a major shear zone across which are significant changes in lithology, structural style, metamorphic grade and gravity and magnetic patterns. In Keewatin District studies were initiated on a major shear zone near Wager Bay and on a major volcanic-sedimentary sequence near Rankin Inlet, which comprises at least two major cycles of volcanic activity.
- In preparation for new geological mapping in Selwyn Basin, Yukon, the stratigraphy and structure were studied near Dawson and Ross River. Both areas have high mineral potential and the detailed geological control obtained is essential to successful exploration.

ENERGY AND MINERAL RESOURCES

- An evaluation of the remaining potential of conventional light and medium gravity oil for western Canada was completed; it showed that more oil remains to be found than previously thought.
- Comprehensive summaries of surface and subsurface information useful to petroleum exploration were completed for the Mackenzie Corridor and will be released as twenty 1:1 million maps and 25 well-log cross-sections in the Open File series.
- Gold, platinum group metals and seafloor massive sulphide deposits were researched. The 'Middle Valley' sulphide mound discovered on the Endeavour segment of Juan de Fuca Ridge is the first seafloor example comparable to economic stratiform base metal deposits on land.
- Mineral resource assessment reports on proposed national parks on Banks Island and northern Baffin Island were completed, and fieldwork was started for reports on sites in the Wager Bay - Southampton Island and Nahanni areas.
- Regional geochemical survey coverage was extended through contract work in Labrador, New Brunswick, Manitoba, Saskatchewan, British Columbia and the Yukon. The results of a similar survey done in 1984 led to a staking rush in northern Saskatchewan.



Sites of proposed national parks: Virginia Falls, District of Mackenzie, N.W.T. (left), and Wager Bay, District of Keewatin, N.W.T. (right).



Scientists use a portable suction dredge for geochemical sampling of heavy minerals in streams.

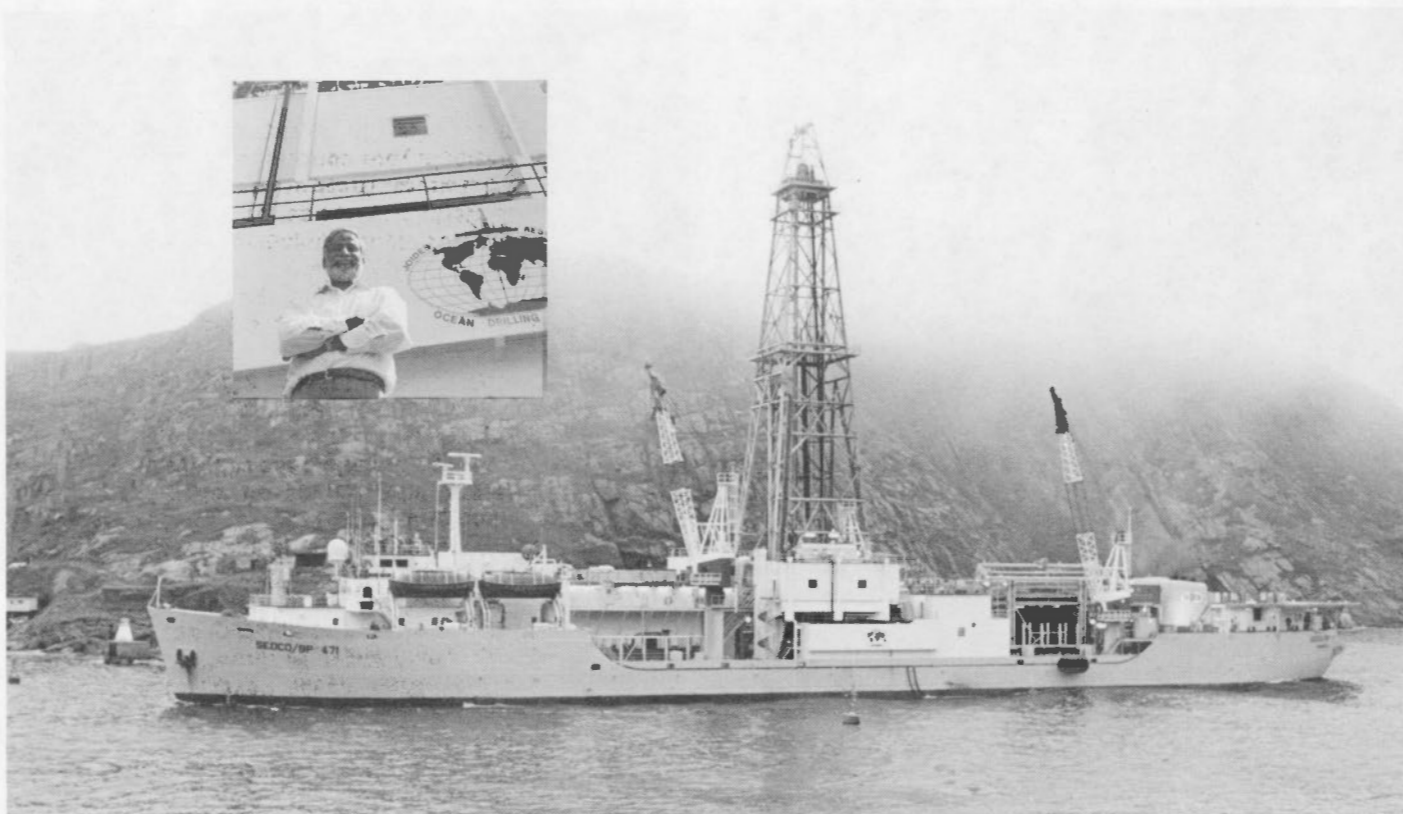


A new three-sensor trigonal aeromagnetic gradiometer system was successfully tested in 1985.

- As part of GSC's objective of developing technology to facilitate mineral exploration, a new three-sensor trigonal aeromagnetic gradiometer system was successfully tested in 1985.
- Fieldwork on the northwestern side of Bowser Basin, British Columbia, has shown that the Lower Jurassic volcanic sequence is much more extensive than thought, thus widening the field for related gold exploration. New

information from the western margin of the basin is leading to a reinterpretation, bearing on coal exploration.

- Biostratigraphic studies in Queen Charlotte Islands show that potential hydrocarbon source and reservoir beds of Early Jurassic and Early Cretaceous ages are more extensive and extend farther south than previously known.
- In the Frontier Geoscience Program, three deep seismic reflection profiles totaling 1500 km were obtained for the southern Grand Banks area, and stratigraphic studies were carried out in the Jeanne d'Arc Basin of the East Newfoundland



Dr. Shiri Srivastava, co-chief scientist of Leg 105 of the Ocean Drilling Program. In the rear is the drillship JOIDES Resolution.

Shelf. An engineering geology capability is being developed at the Atlantic Geoscience Centre to assist offshore hydrocarbon exploitation. Two cores were obtained from the Mesozoic sequence in the Sverdrup Basin for geochemical sampling. Analysis of other drill cuttings has yielded exciting results on biomarker oil-source correlations and maturation histories of the Mesozoic strata which, in the Arctic Islands, contain important hydrocarbon reservoirs and source rocks.

- Aeromagnetic surveys were carried out offshore St-Pierre and Miquelon and over the Beaufort Sea to fix the location of our offshore boundaries. Other geophysical surveys were made of the outer Saint Pierre Bank - Laurentide Channel area and offshore Vancouver Island.
- 1985-86 was the first full year in which Canada was a full participant in the Ocean Drilling Program (ODP): GSC provided support for the creation of a secretariat at Dalhousie University. A GSC staff member was co-chief scientist

on the Baffin Bay - Labrador Sea cruise. Results of participation are directly applicable to the Frontier Geoscience Program. ODP offers the chance to obtain long sediment cores vital for worldwide correlation, data for evaluating climatic changes, and an evaluation of world-class engineering, scientific and analytical techniques.

HAZARDS

- The motion and dimensions of several icebergs in contact with the seabed were fully documented and the resulting deformation was studied from the submersible *Pisces IV*. Pits on the seafloor at Hibernia were investigated.
- In British Columbia, landslides in parts of the Columbia Mountains underlain by metamorphic rocks and in glaciolacustrine deposits in the central part of the province were studied, as well as geotechnical aspects of natural moraine dams in the Selkirk and Coast mountains.

- An evaluation of the potential for shallow- and deep-seated rock mass movements on Parliament Hill in Ottawa concluded that although shallow slope movements will continue no major movements are likely.
- Scientists completed the first phase of a study of the impact of the Norman Wells - Zama Lake pipeline on the environment of the Mackenzie Valley.
- Preliminary studies were done on Richards Island, N.W.T., in cooperation with Indian and Northern Affairs, to determine the usefulness of ground-probing radar geophysical surveys for delineating ground ice. A survey of geotechnical and geocryological conditions of the coastal zone of the Beaufort Sea was continued.

GENERAL

- The GSC gave technical back-up support and advice to the airborne geophysical survey of Thailand by a Canadian company on behalf of the Asian Development Bank and the Thailand Department of Mineral Resources, and gave technical advice on behalf of CIDA for a geochemical survey in Jamaica.
- A two-day Current Activities Forum was held in Ottawa, and the Cordilleran Geology Division participated in the widely attended Cordilleran Roundup sponsored by the B.C. and Yukon Chamber of Mines. ISPG staff organized the

first GSC Oil and Gas Forum in Calgary, combining formal talks and poster sessions.

- People from 15 countries attended a workshop on airborne resistivity mapping. The new applications may help to stimulate interest in airborne electromagnetic surveys.

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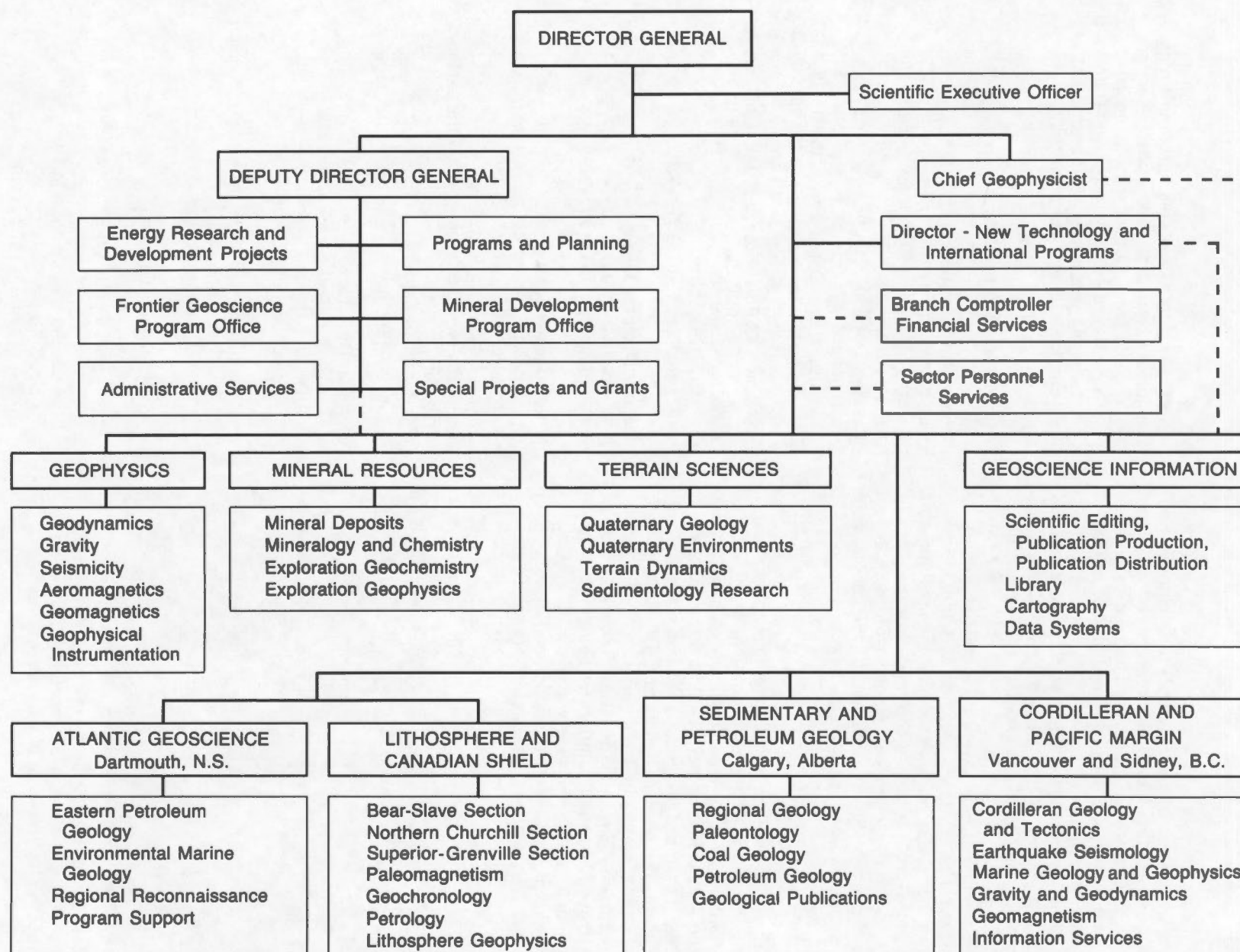
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The new electron microprobe is a fully automated state-of-the-art instrument capable of analyzing minerals in situ for up to any combination of 15 elements.

GEOLOGICAL SURVEY OF CANADA, as of April 1, 1986



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EARTH PHYSICS BRANCH

The Earth Physics Branch ensures the availability of geophysical information and expertise concerning the solid earth, its physical processes and geophysical hazards, as required for public safety and security and for the management of the Canadian landmass and offshore area.

These objectives are met by operating national networks of geophysical observatories; conducting national geophysical surveys; maintaining national data bases in the fields of seismology, geothermics, geomagnetism, gravity and geodynamics; analyzing and interpreting these data to develop new concepts and understanding of the geophysical framework of Canada and of its past and present dynamics; assessing earthquake and permafrost risks and hazards in Canada, including research on forecasting; and applying expertise and knowledge to the solution of such national problems as

- nuclear fuel waste management,
- nuclear test ban monitoring,
- delineation of potential sources of geothermal energy, and
- development of earthquake-resistant construction standards for industrial facilities and other buildings.

Data recorded at Canadian seismic observatories are routinely sent to international centres on the understanding that Canada has access to seismograms recorded by foreign institutions. Such information is often critical to locating and evaluating seismicity along our borders. The branch's seismologists also study the effects of earthquakes elsewhere in the world, so that Canadians may not suffer the consequences of construction failures suffered by other countries.

Off western Canada, many national and foreign vessels successfully conducted research over the Juan de Fuca Ridge near the International Boundary between Canada and the United States. International cooperation was particularly important in providing Canada access to technology that it does not have. Aside from contributing to a national data base that will be important in future discussions on the location of the boundary, this research yielded new insights into the processes currently forming the ridge and its mineral resources.

The major research activities of the Earth Physics Branch are multidisciplinary. Geophysicists collaborate with geologists, astronomers, geodesists, oceanographers and meteorologists in a focused effort to seek solutions to important national problems. At a one-day 'wake' held prior to the amalgamation of Earth Physics with the Geological Survey of Canada, reviews of the branch's accomplishments over the last 40 years underlined the importance of these linkages.

Division of Seismology and Geomagnetism

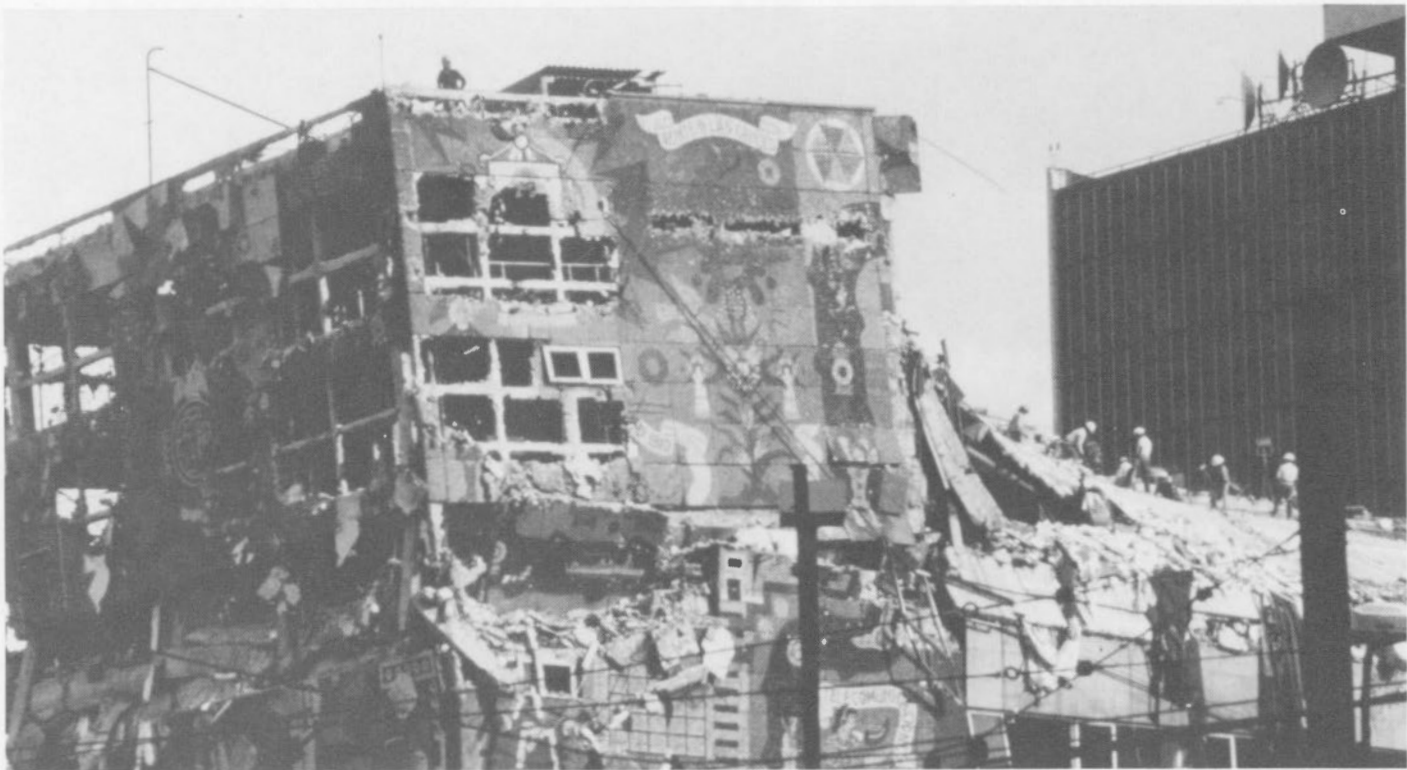
The Canadian seismograph network monitors earthquakes and strong ground motion to evaluate Canadian seismicity and determine regional seismic risk, and provides information on the deep structure of the Canadian landmass and its evolution. The network comprises 16 standard and 38 regional stations. Three stations in northern Ontario monitor regional low-level seismicity in conjunction with Atomic Energy of Canada Limited's Nuclear Fuel Waste Management Program. Data from 21 additional digital seismographs in eastern Canada are recorded in real time at a laboratory in Ottawa, permitting rapid determination of the location and magnitude of eastern earthquakes.

The national geomagnetic network of twelve observatories provides information on the magnetic field across Canada. Electromagnetic induction and paleomagnetic studies provide important information on the structure and tectonics of the Canadian landmass. Magnetic declination (the angle between true and magnetic north) and its secular variation are routinely monitored, and revised charts are published every five years to permit accurate use of magnetic compasses throughout Canada. A 27-day forecast of geomagnetic activity levels and magnetic storms, widely used by industry, is distributed by mail; a three-day forecast is available by recorded telephone message at (613) 992-1299.

1985-86 Highlights

SEISMOLOGY

- Four major seismic events provided staff with opportunities for important studies.
- Seismologists and engineers visiting Mexico City after the September 1985 earthquake disaster learned a vivid lesson on damage sustained by modern-standard 20-storey buildings.
- After the Colombian volcanic eruption of November 1985, staff established a temporary seismic network to observe the volcano's rumblings. This may lead to a joint project, funded by CIDA, to improve volcano and earthquake monitoring in Colombia.
- Staff from Ottawa and Victoria carried out field surveys following the Nahanni earthquakes in the N.W.T. in October and December 1985. Because of remarkable records of strong ground motion Canadian standards for earthquake-resistant construction may be substantially revised.
- In Lithoprobe deep crustal sounding, a Vibroseis reflection survey across the eastern half of the southern Cordillera, carried out through contract to industry, showed that Precambrian basement



Seismologists visited Mexico City after the September 1985 earthquake to assess damage to buildings and other structures.



Seismologists used a microcomputer in a laboratory at the ice island research station in the Arctic Ocean to prepare new portable seismic recorders for operation (one shown on table at operator's right). Developed by branch engineers, this new technology has been transferred to Canadian industry.

rocks continue westward beneath the Rocky Mountain Trench to the Kootenay Arc.

- In collaboration with the Geological Survey of Canada, seismic refraction surveys were successfully completed across the Peace River Arch in Alberta (with industrial and university partners) and across the polar continental margin from the Canadian floating ice island (with the Polar Continental Shelf Project). Both surveys were aimed at understanding the formation and evolution of sedimentary basins, to better assess their hydrocarbon potential.
- In January 1986, Cabinet approved the expenditure of \$3.2 million over three years to modernize the Yellowknife seismological array, which the division operates in support of the arms



This landslide was triggered by the October 1985 earthquake in the Nahanni area of the N.W.T. The nearly vertical lateral scarp (upper centre) had a maximum height of 70 m. Five to seven million cubic metres of material slid down the mountainside, placing the slide in the same class as the well known Hope, B.C. and Frank, Alberta landslides.

control and disarmament initiatives of the Department of External Affairs. The array is used for research on the detection of underground nuclear explosions, a prerequisite to any treaty banning such tests.

GEOMAGNETISM

- Staff from Ottawa and Victoria took part in a successful international electromagnetic sounding of the Juan de Fuca Ridge, the Juan de Fuca Plate and the Pacific continental margin. Investigators from Canada, the United States and Japan operated the largest land and seafloor array of magnetometers ever assembled.

- Paleomagnetic researchers made significant progress, particularly with studies in the Appalachians.
- Staff have progressed well in refining the forecasting of geomagnetic activity to take account of the three geomagnetic zones into which Canada is divided: subauroral, auroral and polar cap.

Division of Gravity, Geothermics and Geodynamics

The gravity program provides maps of spatial variations of gravity over the Canadian landmass and offshore, develops standards for gravity

measurements, applies gravity data to determine crustal structure and to evaluate natural resources, and supports specialists in navigation, geodesy and national defence.

The geothermal program examines the distribution and character of permafrost and gas hydrates, evaluates Canadian geothermal energy potential and investigates tectonic processes to increase our understanding of crustal evolution and resources. Following the investigations of the Task Force on Program Review for Major Surveys, the geothermal energy program was terminated at the end of 1985-86.

The geodynamics program studies the Earth's rotation, polar motion and tides, and investigates crustal stability by measuring temporal changes in gravity, surface movements and groundwater level variations, to improve our understanding of the physical processes affecting the development of the Earth.

1985-86 Highlights

GRAVITY

- More than 3000 new gravity stations and 8250 line-kilometres of sea gravimeter data were added to the national gravity data base through contracted and in-house surveys across the country.
- The division completed a two-year project to edit and process data from 60 marine gravity surveys carried out by the Geological Survey's Atlantic Geoscience Centre, doubling the size of the national gravity data base.
- In exchange for access to the data, the division provided technical supervision to gravity surveys on the east coast contracted to industry by the Department of National Defence.
- Gravity investigations of earth structure were pursued in the Cape Smith and Kapuskasing areas. Gravity measurements and geological mapping were completed on land over the Sept-Îles igneous intrusion, which possesses one of the most intense positive gravity anomalies in Canada.
- In collaboration with Carleton University, staff members gave a course to Canadian astronauts to assist with their training for space-shuttle flights.
- The final results of CESAR (the 1983 Canadian Expedition to Study the Alpha Ridge) suggest that this feature of the Arctic Ocean floor is a massive accumulation of basaltic rock of oceanic origin, one of the largest features of its kind on earth.

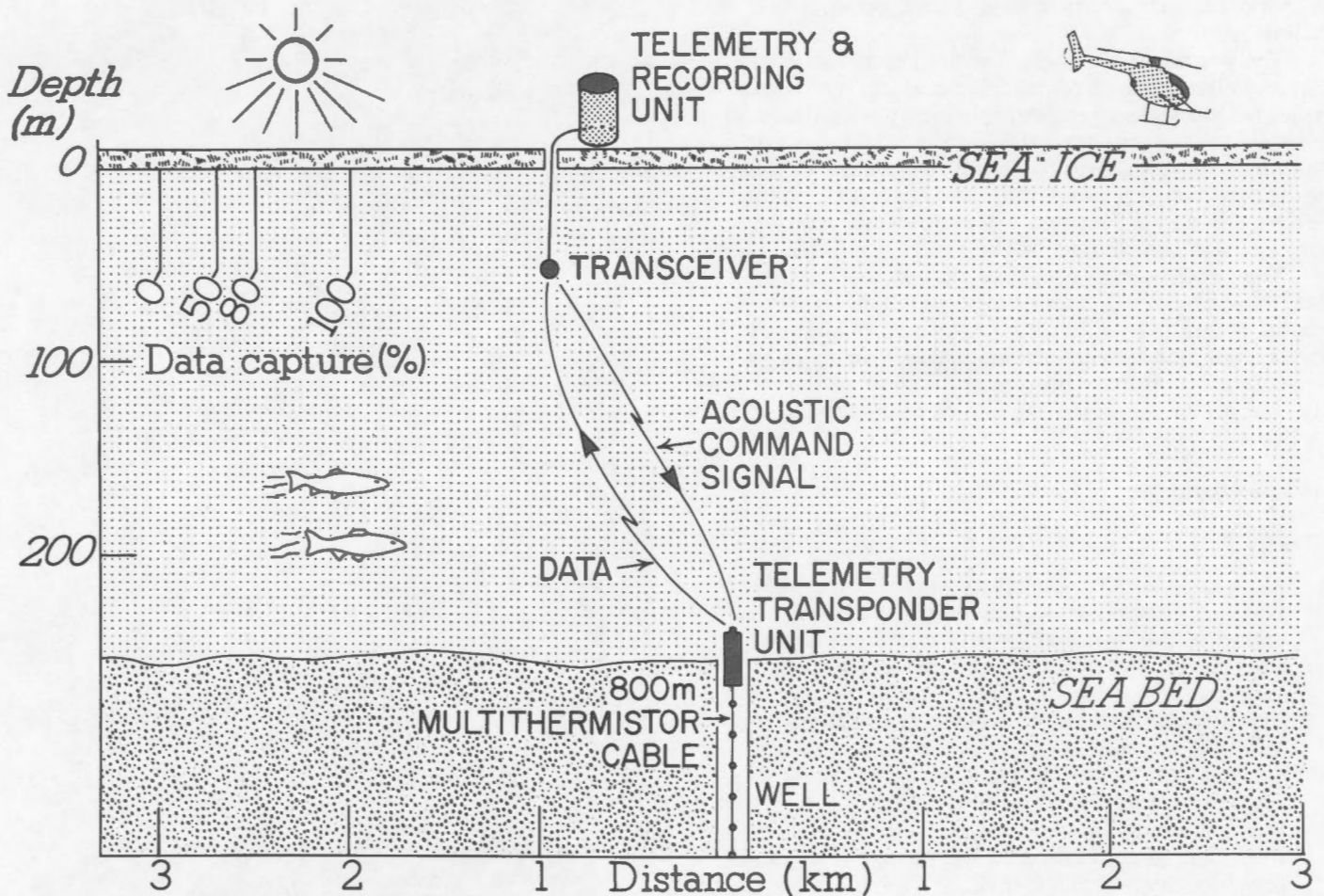


First trials were made of the absolute gravity meter developed in conjunction with the University of Colorado. The acceleration due to gravity is measured through the precise, laser-assisted monitoring of repeated drops of a small mass in a vacuum.

GEOTHERMICS

- A system to measure temperatures in abandoned Arctic offshore oil wells was deployed in a borehole, on the seabed and on the sea ice. This completed the successful demonstration of the technology, developed jointly with industry to supplement measures made in wells on land.

CAPE ALLISON C-47 WELL TEMPERATURE MONITOR



Precise temperatures were recorded in an abandoned Arctic offshore oil well after the disturbance of drilling subsided. Temperatures were sensed by the multithermistor cable. The telemetry and recording unit was removed from the sea ice before the brief season of open water, then replaced after freeze-up.

- Good progress has been made with the analysis of experiments on stresses in frozen ground, conducted cooperatively at the controlled environment facility in Caen, France.
- Two important data files of ground temperatures and permafrost thicknesses in northern Canada have been completed and will be released to users in industry, government and universities.
- Staff contributed to the deep drilling program of the Nova Scotia Department of Mines and Energy, a multidisciplinary study of mineralization in and around granitic plutons.

- A feasibility study was initiated in Springhill, Nova Scotia, on the possibility of using heat pumps to extract energy from the water in flooded coal mines.

GEODYNAMICS

- With Canadian universities, the geodynamics group has completed a Canadian system for long-baseline interferometry (LBI), which promises to be superior for geophysical and geodetical applications to existing astronomical



The telemetry transponder unit was lowered through the oil rig's floor into the borehole, before the well was abandoned.

equipment. A proof-of-concept experiment was to be undertaken in June 1986.

- The 1984 and 1985 NASA mobile LBI measurements between Yellowknife, Penticton and Algonquin Park met their target accuracy of 3 cm over these baselines many thousands of kilometres long.
- Data from the photographic zenith tubes near Ottawa and Calgary and from the collocated Doppler satellite tracking stations, modernized last year, continued to be rated highly by

international agencies concerned with earth rotation and polar motion.

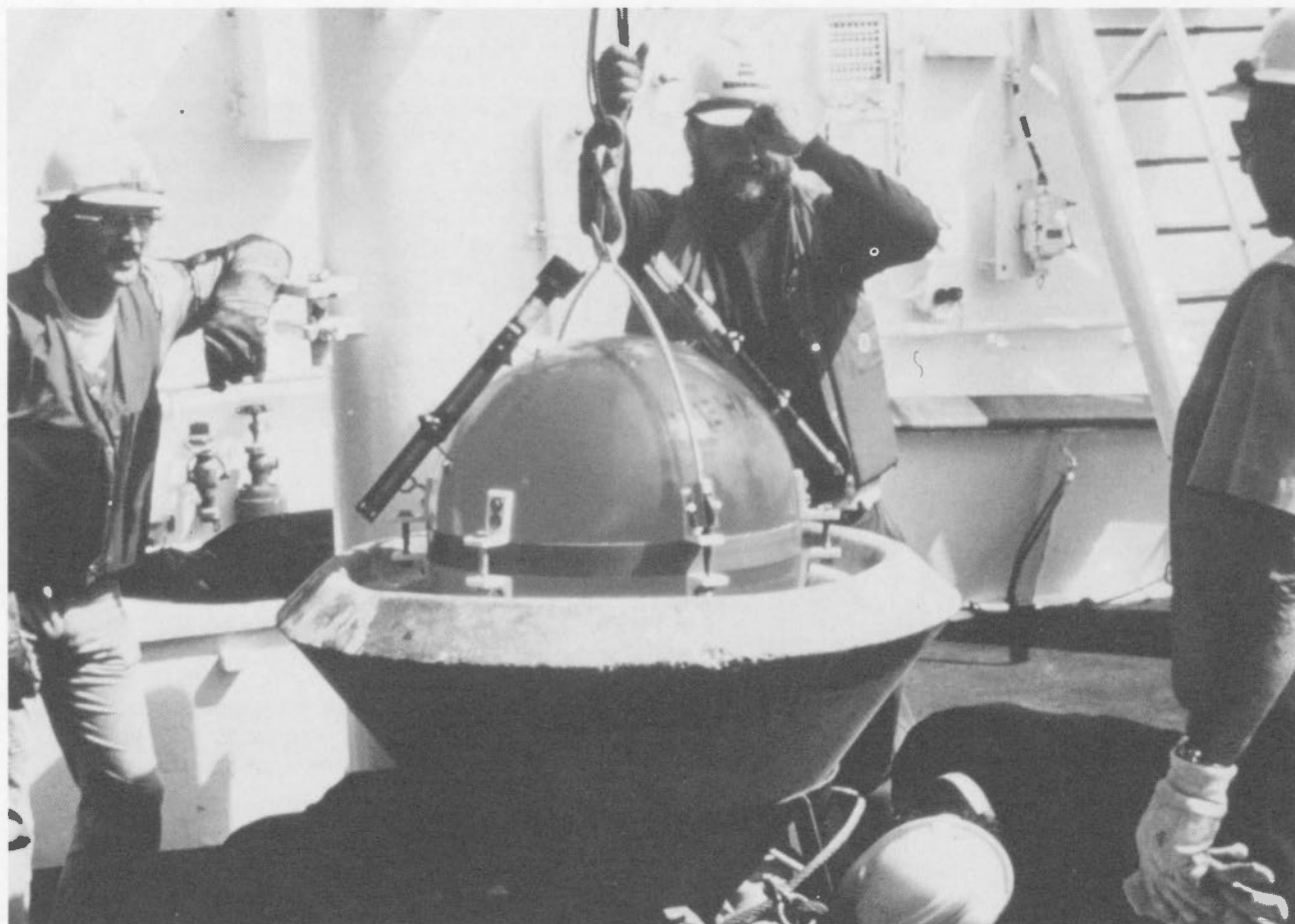
- Expertise developed through the operation of these geodynamics observatories was applied to the precise positioning of the Arctic ice island and of surveys undertaken from the island.
- The division took delivery of a new absolute gravimeter developed under contract with the University of Colorado. It will be used to strengthen the Canadian gravity standardization network and for various geodynamics applications.

Pacific Geophysics Division

The Pacific Geophysics Division is in the Pacific Geoscience Centre (PGC) at the Institute of Ocean Sciences near Sidney, B.C. It is responsible for the west coast operations of the branch and undertakes programs in all five of the geophysical services: seismology, geomagnetism, gravity, geothermics and dynamics. In seismology, it operates an 18-station telemetered digital seismograph network to provide rapid information on west coast earthquakes. In its offshore work, the division cooperates closely with the marine geology unit of the Geological Survey, also located at the PGC.

1985-86 Highlights

- Following the Mexican earthquake division seismologists had many media interviews, and they reviewed hazards to B.C. schools and industrial structures susceptible to earthquake damage.
- Studies on the Juan de Fuca Ridge continued with international cooperation among twenty institutions in six countries. The highlight was the prediction and discovery of a major sediment-hosted sulphide deposit at the north end of the ridge in Canadian waters. The division's bathymetric maps and acoustic imagery were crucial to this exciting work.
- Lithoprobe seismic reflection lines on Vancouver Island were extended across the continental margin with marine multichannel data, through contract to industry, to give a comprehensive cross-section of the margin subduction zone.
- Comprehensive data bases compiled over the last two years for the Juan de Fuca and Beaufort Sea boundary zones will permit rapid and effective response to External Affairs' requests, and will be of use in other geoscience programs.



The spherical pressure case housed an ocean-bottom magnetometer ready for deployment on the Pacific seafloor. At the end of the experiment, a coded sonar signal sent from the recovery ship released the instrument to float free from its concrete 'flower-pot' anchor.

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