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NEW DIRECTIONS for GEOSCIENCE

GEOLOGICAL SURVEY OF CANADA
COMMISSION GÉOLOGIQUE DU CANADA

FEB 18 1995

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Geological Survey of Canada

1993-94



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Cover: *This mosaic of geoscience datasets from the NATMAP Shield Margin Project exemplifies GSC's new approach to geoscience surveys and the use of state-of-the-art information technologies. NATMAP, GSC's national geoscience mapping program, brings together researchers from a broad spectrum of geoscience fields and agencies (government, industry, university) to collectively generate new multidisciplinary perspectives on areas of significant economic potential and/or environmental interest across Canada. NATMAP is featured on page 12.*

The datasets displayed on the mosaic were acquired and integrated as part of the NATMAP Shield Margin Project's initiative to develop a comprehensive digital geoscience database for the project area. This resulted in the release of a CD-ROM containing these and other datasets, including new geological maps produced through unprecedented federal-provincial cooperation. More information about the CD-ROM can be found on page 23.

1. *Geology of the Precambrian Shield*
2. *Hue-saturation-value colour composite of geology and shade relief magnetics*
3. *Winter satellite image (LANDSAT Thematic Mapper Sensor)*
4. *Black and white image of total field aeromagnetics (shaded relief) with Precambrian bedrock geology contacts*
5. *Colour image of Bouguer gravity with Precambrian bedrock geology contacts*
6. *Combined Bouguer gravity (colour) and total field aeromagnetics (shaded relief) with Precambrian geology contacts (bedrock in upper block and sub-Phanerozoic in lower block)*

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The Geological Survey of Canada (GSC) is Canada's premier agency for geoscientific information and research, with world-class expertise focussing on geoscience surveys, environmental issues and technology innovation.

GSC supplies the fundamental national geoscience perspective required to support effective mineral and hydrocarbon exploration and development across Canada, to provide the geological basis necessary to understand and address environmental issues, and to advocate the interests of Canadian geoscience at the international level.

GSC has an extensive capability in onshore and offshore geoscience surveys and in interpreting and managing geoscience information. Expertise is applied to energy and mineral resource assessments, natural hazards, environmental issues, and the development of exploration technology. GSC exists to support the Canadian economy, but also works with industry and other government organizations in many regions of the world.

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NEW DIRECTIONS FOR GEOSCIENCE

A Message from the Assistant Deputy Minister of the Geological Survey of Canada

The saying "If it's not grown, it's mined" sums up the fundamental contribution of the geosciences to the high quality of life Canadians enjoy. But it doesn't go far enough. The geosciences have an equally and increasingly important role in the understanding of the many pressing environmental questions we must, as a society, address.

It is my belief that the future success of geoscience in Canada depends upon the effectiveness with which the geoscience community adapts to the dramatic changes that are reshaping society at every level. Each of us, whether in industry, government or university, is now developing the strategies necessary to adapt our organizations to the new realities of increased competitiveness in the global markets facing Canadian goods and services, the need to balance environmental concerns with economic development, shrinking research budgets, and growing demands for non-traditional types of geoscience, especially linked to environmental issues.

The challenge we are facing is complex, but not at all insurmountable. We have seen in the past few years a dynamic movement within the geoscience community at all levels to work together, to pool resources, to plan more strategically and to sell geoscience as part of the solution to

many environmental problems. The result has been more efficient, relevant and innovative science.

But what are we doing at the Geological Survey of Canada? What are our new directions?

First and foremost, cooperative work is now prominent in all our activities. I am particularly pleased with the results of our strengthened connections with provincial and territorial geological surveys, which are most advanced with Alberta and British Columbia. Coordinated annual planning, carried out on an agency-to-agency basis or under the auspices of the National Geological Surveys Committee, is ensuring optimum use of resources and eliminating any possible overlap in our research programs. Cooperation and sharing of facilities, aimed at cost efficiencies and maximum relevance of science, are the touchstones of our joint planning efforts.

We are also continuing to develop mechanisms to encourage connections with industry. Our Industrial Partners Program completed its second year of operation with 75 Canadian companies partnered with GSC scientists (the program is described on page 16). Similarly, we are continuing to shape GSC programs to fit needs expressed by our clients. An excellent example is a



During the past year, the B.C. Geological Survey and GSC took a big step towards integrating their work when 40 scientists from both groups met to develop a joint strategic plan for geoscientific mapping in support of mining in the province. The meeting, which was a first for both organizations, produced a strategic plan which is a blueprint for building new initiatives and for further integrating work. It also promotes stronger working relationships and encourages economies of scale. The plan was strongly endorsed by industrial advisory committees of both organizations.

consultation last fall with Toronto-based clients, mainly in the mining industry, that led to an agreement with the Ontario Government to provide access to GSC library services and publications through the Toronto office of the Ontario Geological Survey.

On the global front, GSC, through our new International Office, is lending its weight to representing the interests of Canadian industry abroad. We are aggressively promoting a "Team Canada" approach — in effect, GSC plays an advocacy role to assist the sale of Canadian geoscience industry products and services outside of Canada. The International Office has had a productive first year of operation. Of particular note is its success in catalyzing Canadian

participation in an exciting new project in South America with the Inter-American Development Bank, one that may lead to opportunities for Canadian industry.

Finally, technological innovation is opening up radical new ways of working. LITHOPROBE, an internationally renowned Canadian research program, is aimed at answering major geoscientific questions about the deep structure of the Earth. To do so LITHOPROBE is developing technologies that enable us to see into the Earth as never before possible. The transfer of some of these to Canadian industry and their subsequent commercial development has been very successful (GSC's participation in LITHOPROBE is described on page 8).

Similarly, the use of computers is revolutionizing fieldwork and enabling us to more quickly deliver the resulting maps and interpretations to clients who need them — Canada's leadership in this field is underscored by the large number of delegations from other countries who visit us to learn our techniques. The fast-breaking developments in information systems are also catalyzing new applications and connecting diverse specialists. NATMAP, Canada's national geoscience mapping program typifies this trend. It blends skills from a variety of partners and incorporates the latest computerized information technology to deliver new geoscientific information to clients in the exploration industry (NATMAP and its current projects are described on page 12).

Changing times and priorities are having a great impact on the programs and outputs of the Geological Survey of Canada, and driving us in exciting new directions. I invite you to take a close look at our new way of doing business and would welcome any questions or ideas you may have about how we can work together.

Elkanah A. Babcock
Assistant Deputy Minister
Geological Survey of Canada

GEOSCIENCE SURVEYS

*Geoscience at Work Across the Country:
Some examples from 1993-94*

The Geological Survey of Canada carries out geoscience surveys — both geological and geophysical, land and marine — that are regional in scale, national in scope and global in perspective. The result is a national geoscience information base accumulated through field surveys, laboratory investigations and multidisciplinary research. It provides the foundation for all GSC activities and is an integral component in mineral and energy resource exploration and the subsequent effective development of these resources. It also provides the geoscience basis essential to any understanding of environmental questions and the management of sustainable development.

Gravity Mapping Milestone

Reconnaissance gravity mapping of the Canadian Cordillera was completed this year. During a three-year period, more than 5000 gravity stations were observed over an area of 450 000 km² encompassing parts of the Yukon, Northwest Territories and northern British Columbia. GSC's partners in this major achievement included the U.S. Defense Mapping Agency, the Mapping and Charting Establishment, National Defence, and the Geodetic Survey. The gravity data collected will aid resource exploration and structural studies, help to better define the geoid for the surveying industry, and contribute to North American Defence Plan requirements.

Regional Geology

Mapping of Grenville geology continued in the region of Saint-Maurice, Quebec, as follow-up to the discovery in 1990 that confirmed the economic potential of the central portion of the Grenville province (mineralized metasedimentary sequences were found in a belt of highly metamorphosed supracrustal rock which was correlated with the assemblage of volcano-sedimentary rocks from the Montauban Group, a classic mining area). A 1:250 000 scale compilation map is being prepared in the regions of Shawinigan and La Tuque to identify areas of economic interest on a larger scale.

Prairie Regional Surveys

Data from soil and till sampling carried out from Calgary to Winnipeg in 1991 continues to influence diamond exploration in the Prairies, while environmental applications of the data in the fields of landuse, hydrogeology, and health are attracting much attention. In 1992, as follow-up to this work, GSC completed the first low-density geochemical survey in Canada, over 1000 randomly selected sample sites in an area of 735 000 km². The survey focussed on the trace element concentrations in soils and tills, and heavy minerals in tills. It revealed the presence of diamond indicator minerals in areas that had not previously attracted

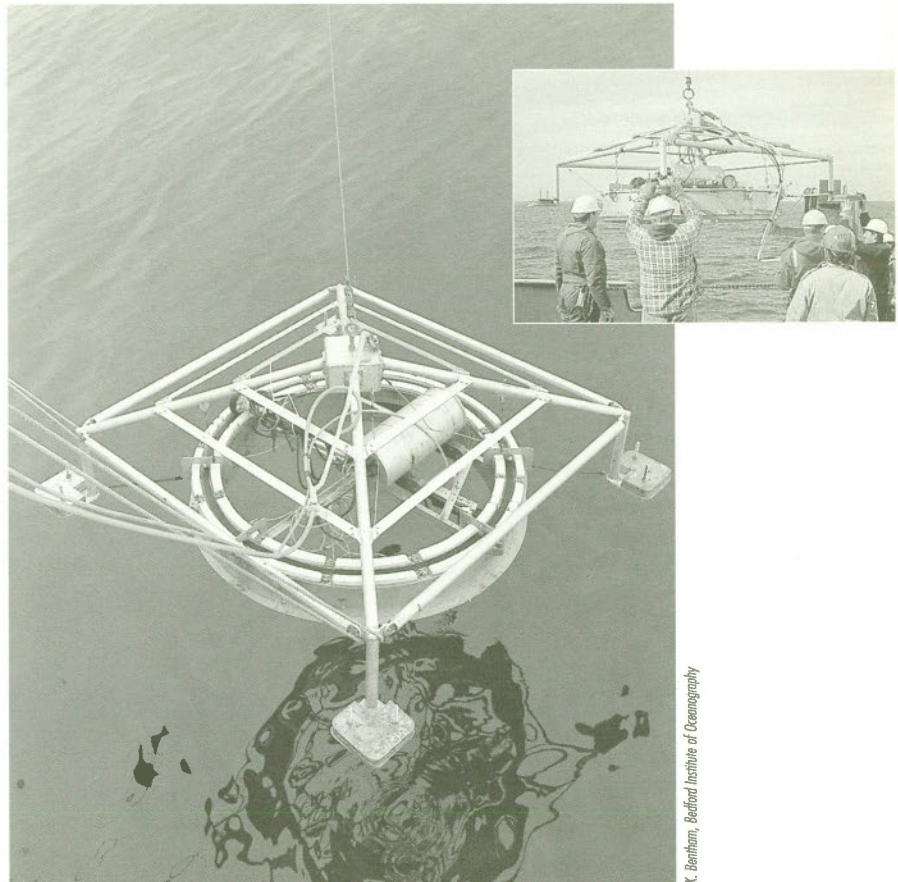
exploration interest. Moreover, broad regional geochemical patterns emerged that have environmental significance. GSC scientists are working with colleagues at Agriculture Canada to investigate the natural sources and processes that influence the uptake of heavy metals by grain crops.

Lake Winnipeg Initiative

The Prairies program was supplemented with a new regional survey that responds to client requirements for information on the structure of bedrock in the Lake Winnipeg region, the causes of shoreline erosion on the lake, and the processes controlling the distribution of toxic substances in this important body of water. A research partnership, co-led with Manitoba Energy and Mines, was signed with Manitoba Hydro, the Province of Manitoba, Fisheries and Oceans Canada, and the universities of Manitoba and Winnipeg. The Canadian Coast Guard will contribute the use of a ship, and GSC has led the design of a 1994 survey of the Lake Winnipeg environment.

Fraser Delta Geoscience Survey

The Fraser delta on the Lower B.C. Mainland just south of Vancouver is a densely populated and highly industrialized region that lies in one of the most seismically active regions in



K. Benham, Bedford Institute of Oceanography

Seafloor Stability: Environment Canada is funding a GSC assessment of the stability of various sites for disposal of materials which are dredged from the Saint John (New Brunswick) and other harbours on a regular basis. Conditions at the site chosen must be such that the dredged material will not flow into areas important for fishing or tourism, or in any way endanger the environment. The Sea Carousel, developed by the GSC, can measure the potential for suspension and redistribution of dredged sediment on the harbour floor.

Canada. As part of ongoing multi-disciplinary studies to gain a better understanding of ground responses in large earthquakes, GSC drilled two 300 m-deep holes, 4 km apart, in the delta. The results will fill gaps in the geological, geophysical, and geotechnical knowledge of the delta and help develop a better understanding of earthquake vulnerability. Goals for the work were established after extensive consultation with

geotechnical engineers, academics, and other federal and provincial government agencies. The field phase of the project pulled together the expertise of a number of GSC scientists and field engineers from two local geotechnical companies. Preliminary results indicate that the delta's geological architecture is far more complex than previously recognized. This knowledge will help refine models of the delta's subsurface

Focus on: Landslide Hazards in Canada

Landslides are a major geological hazard in many parts of Canada, and studying them is an important part of GSC's national responsibilities linked to investigating and evaluating the effects of geological hazards on public safety, economic development and the environment. The most well known landslides occur in the steep, mountainous terrain of the Cordillera where frequent destructive events have had major effects on communities, fisheries, forestry, strategic transportation corridors and land development. GSC studies show that rock avalanches (some reaching velocities of 100 metres/second) and debris flows caused by heavy rains are the greatest threats.



The Attachie landslide occurred suddenly in the night of May 26, 1973, along the Peace River 88 km west of Fort St. John, B.C. The landslide involved 12.4 million cubic metres of fine-grained Pleistocene materials and blocked the Peace River for about 12 hours. Joint work in 1993-94 by the GSC and B.C. Hydro has attempted to establish the geological and geotechnical factors that led to the landslide and to unravel the mechanism by which some of the debris travelled very rapidly over the flat Peace River valley floor over a kilometre from its source.

Recent GSC landslide research includes:

- Work in Jasper National Park by GSC has shed new light on the conditions leading to rapid large-scale rock avalanches similar to the devastating Frank Slide in 1903, which caused 76 deaths. Also in Jasper, cooperative work with B.C. Hydro is aimed at a better understanding of the mechanism of massive rapid flowslides that have occurred in an area proposed as a hydroelectric reservoir.
- Landslides in the sensitive clays of the St. Lawrence Lowlands have caused considerable property damage and 92 deaths since 1840. The most recent event at Lemieux, Ontario, resulted from the failure of a soft clay zone after an unusually wet spring in 1993. Following the Lemieux landslide, the GSC expanded its eastern landslide studies in an effort to improve understanding of the geological controls and mechanisms of landslides in this region.
- An inventory of landslides was compiled for 420 000 km² in NWT's Mackenzie Valley and adjacent mountains. Results of this work will aid the design, routing and siting of northern pipelines, roads and infrastructure. In a long-standing partnership with Interprovincial Pipeline Ltd., GSC investigates the stability of sensitive slopes along the Norman Wells to Zama pipeline to ensure pipeline integrity.
- GSC provides ongoing advice to other agencies, such as power utilities and provincial and local governments involved in the regulation of land use, and assists in the investigation of transportation accidents (e.g. train derailments) caused by landslides. On the international level, GSC is involved in a cooperative research project with Kyoto University, Japan, involving the prediction and occurrence of rapid landslides.

geometry used to estimate potential ground motion amplification during a major earthquake — a prime concern in the design of tall buildings, bridges, and other large structures.

Seafloor stability is another important aspect of geoscience applicable to the Fraser delta. Sediments deposited at the river mouth tend to be unstable, and GSC scientists have located old, massive underwater slope failures near the large B.C. Ferries Corporation's Tsawwassen Terminal, the Roberts Bank super port, and the underwater cable crossings for both power and telephone lines to Vancouver Island. Studies are continuing to locate and assess these underwater hazards. GSC and B.C. Hydro have developed a two-year joint program to carry out risk analysis of slope stability in the area. The cost of replacing the underwater power line to Vancouver Island should it be damaged by slope failure is estimated at \$500M, and the southern island could be left without power for months.

Ocean Mapping Program

GSC is a participant in a multi-agency program along with federal and provincial governments, universities and industry. The program allows all partners to achieve their specific research goals while

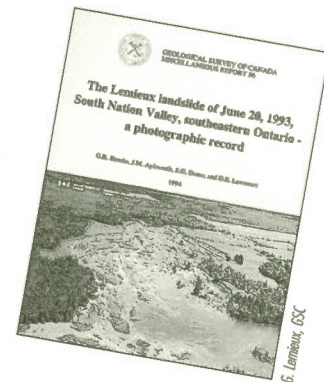
minimizing the high costs of ocean research through collaboration. Ocean mapping activities will help meet GSC mandates for mapping and related scientific research, provide unique expertise and services to other government sectors, and assist Canadian industry in developing a world-class marine surveying capability. By cooperating with the Canadian Hydrographic Service and Canadian industry, and tapping into its own expertise, the GSC has recently made dramatic progress in its ability to visualize seafloor data. The eventual goal is automated seabed classification.

The Scotian Shelf research cruise of the naval ship *HMCS Moresby* off Sidney, Cape Breton, is a good example of the benefits of shared research. The data collected was used by the Department of National Defence for defense objectives linked to strategic Canadian harbours; by the Canada Centre for Mineral and Energy Technology (CANMET) to examine the condition of collapsed, underwater coal mines with a view to assisting in the design and safe planning of future underwater mines; and by GSC and its industry clients to identify sediments and bottom conditions suitable for the routing of the Trans-Atlantic fibre optic cable between Nova Scotia and Ireland.

LEMIEUX LANDSLIDE

On June 20, 1993, a large landslide in sensitive clay occurred near the former townsite of Lemieux, Ontario. The failure involved 2.5 to 3.5 million cubic metres of sand, silt, and clay which flowed into South Nation Valley inundating 3.3 km of the valley and blocking the river for two days. The landslide scar, 680 m long and up to 320 m wide, covers 17 hectares.

This slide is the most recent of a number of historic and ancient landslides which characterize this part of South Nation valley and are a major concern for local residents and regulatory authorities. Prior to the slide, properties in Lemieux had been expropriated by the Ontario government and local residents moved. While the costs associated with the Lemieux slide and the earlier expropriations were steep (about \$5M), the savings in terms of public safety are immeasurable.



GSC investigated the slide and published a photographic report *The Lemieux Landslide of June 20, 1993, South Nation Valley, Southeastern Ontario - A Photographic Record* by G.R. Brooks, J.M. Aylsworth, S.G. Evans and D.E. Lawrence. 18p. (GSC Misc. Report 56). \$5.00 in Canada, \$6.50 outside Canada. Ordering information can be found on page 29.

Focus on LITHOPROBE:

Advances in Airborne Gamma Ray Spectrometer Surveys

As a result of GSC research over the past three years, airborne gamma-ray spectrometry (AGRS) is finding new applications in the exploration for gold-rich porphyry deposits in the Canadian Cordillera. These deposits are characterized by the development of potassium-rich alteration minerals which may be detected either *in situ* or in glacial overburden. On the basis of a successful pilot project conducted in the Mount Milligan area in 1991, further surveys have been flown in the Fish Lake, Mount Polley, Clisbako and Tchentlo areas in addition to new surveys in the southern Mount Milligan region. There were two firsts for GSC's AGRS program in 1993: the first survey, funded by TECK Corporation, was flown in the Afton area, and GSC mounted its first helicopter-borne AGRS survey in the Yukon's Casino district.

Aeromagnetic Surveys

High resolution aeromagnetic surveys totalling 147 000 line km were flown in British Columbia, Saskatchewan and Manitoba. These surveys were funded partly under Federal-Provincial Mineral Development Agreements, partly by industry partners, and partly by GSC. The aeromagnetic survey of the interior plateau of British Columbia (110 000 line km) is a two-year project that will support detailed geological mapping being carried out under the Canada-British Columbia Mineral Development Agreement. The Saskatchewan (23 000 line km) and Manitoba (13 800 line km) surveys are the third year of a multi-year program that meets the dual objectives of mapping the Precambrian basement of the Western Canada Sedimentary Basin and of providing a fundamental tool for kimberlite exploration.

LITHOPROBE, Canada's national multidisciplinary geoscientific research project, is looking deeper into the Earth with higher resolution than has ever been possible before (to depths of up to 50 km). The goal is to develop a comprehensive knowledge of the evolution of the North American continent from four billion years ago to the present. Besides giving scientists new insight about Canada's deeper structure, the information coming out of LITHOPROBE activities is contributing to mineral and hydrocarbon exploration in Canada, and to understanding of earthquake hazard and volcanic activity.

Technological innovation is another benefit of LITHOPROBE. Seismological and electromagnetic instrumentation developed principally by GSC scientists for LITHOPROBE activities has been transferred to Canadian companies and marketed world-wide. Seismological studies developed for deep crustal studies are also being adapted and applied for mineral exploration in crystalline rocks.

The largest and most successful project of its kind ever undertaken in Canada, LITHOPROBE is based on strong collaboration between partners that include universities, industry, and the GSC and its provincial and territorial counterparts. This ensures the relevance of its activities to geoscience initiatives

SURVIEW

Digital releases of GSC's multiparameter airborne geophysical surveys now include **SurView**, a data display program developed in-house. It provides facilities for viewing and printing a variety of data including grid data,

flight lines, profile maps, stacked profiles, general purpose polygons (geology and geography), text and symbols. **SurView** operates in the Windows environment on most microcomputers.

Investigating Canada At Depth

throughout Canada. In 1993-94 there were about 100 scientists working on LITHOPROBE projects across Canada.

LITHOPROBE involves geophysical, geochemical and geological surveys along selected broad swaths (transects) to assess three-dimensional earth structure and understand past geotectonic processes. Each transect (there are ten at various stages of completion) focusses on carefully selected geological features that represent key questions relevant to the growth of Canada's landmass, as well as globally significant processes.

Principal funding totalling about \$4M annually comes from the federal government through the Natural Sciences and Engineering Research Council of Canada, with another \$1.6M in scientific services from the GSC. Coordination is provided by The LITHOPROBE Secretariat which is housed at the University of British Columbia. The Geological Survey has been an active participant since LITHOPROBE's inception in 1984; in 1993/94, GSC was involved on three transects.

- In **northern Manitoba and Saskatchewan**, three major surveys (seismic reflection and refraction, and electromagnetic measurements) were conducted as part of the "Trans-Hudson Orogen" transect, named after the orogen that welded together eastern and western Canada

some two billion years ago. The results have increased understanding of ore deposit settings in this mineral-rich area. In November, GSC scientists presented preliminary results of a LITHOPROBE-related INCO-GSC high resolution seismic reflection program to representatives of INCO's Exploration Division at Thompson, Manitoba. The Thompson area was selected in order to obtain a better understanding of known nickel sulphide orebodies, and to assess the area's potential for new ones. GSC scientists developed specialized processing methodologies to produce highly refined seismic images of the complexly deformed Thompson area, and integrated these with geological constraints provided by GSC geologists. In March, a controlled-source EM survey, led by the GSC with additional financial contributions from INCO and LITHOPROBE, was conducted to further resolve the subsurface extent to which ore deposits are hosted at the Thompson mining camp. Results will be published within the next year.

- In **Ontario and Quebec**, work on the Abitibi Grenville transect focussed on another economically important and mineral-rich region: the Archean Abitibi greenstone belt and the Middle Proterozoic Grenville orogen. In 1993, LITHOPROBE acquired 924 km of regional seismic reflection data and 38 km of high-resolution

data in the final stage of seismic acquisition for this transect. For the Earth's early history, current results from the Abitibi and Grenville Province indicate mountain building processes that involved stacking of crustal slices — processes comparable to those of modern continental mountain chains. Work also continued in the Sudbury region to extend our knowledge of the formation and evolution of the Sudbury structure, Canada's richest mining area.

- In **Alberta and British Columbia**, investigation of the crustal structure of the Western Canada Sedimentary Basin continued with a 650 km long deep-reflection seismic line over the Peace River Arch of northwest Alberta-northeast British Columbia. This region contains several important oil and gas fields, and the 1994 seismic reflection line will cross a number of these hydrocarbon production trends. The line links two similar deep reflection seismic lines: one, the 1992 LITHOPROBE line in central Alberta; the other, an industry line along the Alaska Highway. Together these three lines will provide one of the longest sets of continuous deep-seismic lines available for any sedimentary basin in the world. About two-thirds of the cost of the 1994 deep reflection line will be provided by the 23 companies participating in the 1994 GSC-industry consortium.

MINERALS

The objective of the GSC's Minerals Program is to provide comprehensive knowledge of the distribution and origin of Canada's mineral resources, mineralogical and chemical expertise and services, and assessments of domestic and foreign resource potential, as well as to develop new exploration concepts and technologies. It also includes leading-edge research in mineralogy and analytical chemistry which is an essential underpinning of a broad range of the GSC's work.

New Type of Gold Mineralization Recognized in Canadian Shield

Quartz veins have been the main source of gold ore in Canada for much of this century, in part because they were relatively easy to find due to their obvious contact with their host rocks. With the discovery in 1981 of the world-class deposits at Hemlo, Ontario, geologists became increasingly interested in deposits where quartz veins were not the controlling factor, and where gold is subtly disseminated in volcanic and sedimentary rocks. Working in collaboration with Cameco Corporation, GSC scientists have recognized that a gold occurrence in metasedimentary rocks at Greywacke Lake in Saskatchewan's LaRonge District bears many similarities to Tarkwa and other important gold deposits in west

Africa. This is the first such mineralization to be identified in the Canadian Shield and indicates that previously ignored sedimentary belts are prospective for gold.

Discovery of Titanium-Vanadium-Phosphate Deposit in New Brunswick

In the course of investigating anomalous fluoride concentrations in groundwaters in the Moncton area of New Brunswick, a GSC scientist re-examined core and logs from drilling carried out by oil and gas companies in 1919, 1931 and 1970. Although titanium mineralization had been observed in this early drilling, it was not believed to have economic potential. The GSC's re-interpretation of the geological setting and discovery that the deposit also contains vanadium and phosphate were presented to industry at the 1994 Minerals Colloquium. A significant claim-staking and exploration program by a major Canadian company resulted.

Bedrock Mapping and Diamond Exploration

Diamond exploration in Canada now encompasses virtually every region of Canada where Archean rocks are exposed or lie buried beneath

younger rock sequences. GSC expertise and products applicable to diamond exploration are in great demand by the exploration industry. A prime example is GSC's new CD-ROM 1:1 000 000 geological compilation, accompanied by a paper map, for the main diamond play in the Northwest Territories (see page 23). GSC participation in LITHOPROBE seismic reflection and refraction studies of the prairie provinces has also provided new insight applicable to diamond exploration: in the Trans-Hudson orogen area, the presence of a crustal root in north/central Saskatchewan, along a strike with the major kimberlite discoveries in the Prince Albert area, indicates that the crustal structure there may be favourable for diamondiferous kimberlites. Seismic tomography suggests a similar structure on Ellesmere Island.

New Understanding of Sudbury Basin

The Sudbury Structure continues to receive attention as the oldest (1.85 billion years) and largest (originally 250-300 km in diameter) impact structure in North America, and as the site of Canada's largest mining camp. Recent advances in understanding the cratering process and the results of a cooperative LITHOPROBE transect



43 m layered gabbro sill intruding Proterozoic dolostones in the Brock River Canyon, Northwest Territories.

C. Jeffcoat, GSC

involving GSC, industry and academia have resulted in a model in which all the major lithologies, including the world-class copper and nickel deposits, can be attributed to the impact event.

Mineral Potential in Alberta

As part of the federal-Alberta Mineral Development Agreement, a team of GSC and university scientists are mapping shear zones in the Precambrian Shield of northeast Alberta to help determine the province's mineral potential, with a special emphasis on diamond exploration. Products will include 12 mapsheets at 1:50 000 scale, all of which will be available as digital files. So far, five have been completed and published as GSC Open Files.

MINERAL POTENTIAL ON FEDERAL LANDS

Access to lands for mineral exploration and development is a key issue for northern communities and the mineral industry. Through the Mineral and Energy Resource Assessment process (MERA), GSC provides regional mineral potential analysis for areas of Canada that fall under federal jurisdiction and may be subject to exploration and development restrictions pending decisions on the location of new national parks. In addition to their immediate applications to land use decisions, MERA assessments identify prospective areas for exploration. For example, results of 1993 field work for a MERA program conducted on Victoria Island in the Arctic revealed potential for the occurrence of nickel-copper deposits, strongly resembling those at the Noril'sk deposit in northern Russia. An extensive exploration program by industry is underway. MERA work in the Wager Bay area, published in 1993, demonstrated potential for iron formation associated with gold and komatiite-hosted nickel deposits.

Focus on NATMAP: Canada's National Geoscience Mapping Program

NATMAP was developed by the GSC and started in 1991 to provide opportunities for collaboration among scientists from the GSC and provincial surveys, industry and universities in field-based projects across the country. NATMAP provides coordination and funding support to mapping projects that assist Canada's mining industry, fill gaps in our knowledge of Canada's geology, or address questions related to environmental or other societal issues.

NATMAP participants are leading the development of digital mapping standards and applications of digital technologies to interpret multiple datasets and to produce a wide variety of geological maps. In 1993-94, five NATMAP projects operated across Canada.

- In Manitoba and Saskatchewan, NATMAP's Shield Margin project spearheaded the integration of the results of systematic bedrock and surficial mapping, new and existing geophysical surveys and data from thematic studies in the Flin Flon belt, culminating in the release of a comprehensive database in an innovative CD-ROM format in December 1993. This project, which involved scientists from the Manitoba and Saskatchewan geological surveys, GSC, universities and industry, has made fundamental contributions to the development of a new framework for regional base-metal exploration in the Flin Flon area and in

Precambrian rocks beneath the Paleozoic cover to the south. In addition, detailed study of the tectonostratigraphic assemblages in the Flin Flon belt has revealed first-order magmatic and structural controls on the stratigraphic and structural settings of the Cu-Zn volcanic-associated massive sulphide deposits.

- In the Northwest Territories, the Slave NATMAP project is working to further understanding of the geological evolution and mineral potential of the Slave Province. Partners include the GSC, the NWT Geology Division of the Department of Indian and Northern Affairs, the Canada-NWT Mineral Initiatives Office of the territorial government, and several universities. This project continues to provide important insights about the geology of the Slave Province, including major tectonic boundaries, distinct lithotectonic assemblages, geochronology, and the implications of these for mineral potential evaluation.
- The Prairies NATMAP project is developing a unified stratigraphy for the surficial geology of the southern Prairies from the Ontario border to the foothills of the Rocky Mountains in Alberta. In addition to mapping the surficial geology, participants have compiled data from more than 10 000 water well and other boreholes, and developed a new methodology

for interpreting borehole data that is being further tested and applied in other areas in Canada. End-uses of the resulting information are broad and far-ranging: for example, surficial geology information can be used for siting of sanitary landfills and for protecting groundwater wells from pollution - a particular concern because of drought conditions in recent years. It will also augment existing sand and gravel inventories and document the potential for landslides which are the principal geological hazard in the region.

- The Southern Alberta NATMAP project completed its first field season in 1993. Its goal is to accelerate the mapping of the bedrock and surficial geology of 13 1:50 000 scale mapsheets from the International Boundary to the Turner Valley area, initially involving the Blairmore, Cardston, Maycroft and Waterton Lakes areas of southwestern Alberta. The project draws on the expertise of GSC, the Alberta Geological Survey and several universities. It is generating much interest in the petroleum industry because this major oil and gas production area has not been studied in such detail since the 1950s. Several companies are providing access to their reflection seismic data and scientific expertise, both of which are essential in the construction of accurate cross-sections in the deformed terrain of the Rocky Mountain Foothills. The project will also gather information on mineral occurrences, potential aquifers

and natural hazards. Results will be released as paper maps, reports and a GIS-based digital database.

- The Oak Ridges NATMAP project is an exciting collaboration, jointly led by the GSC and the Ontario Geological Survey, to study the Oak Ridges Moraine in the Greater Toronto Area. The moraine is an important source of aggregates and a major recharge area and aquifer system for this heavily populated region. The Oak Ridges NATMAP project will update the Quaternary geology of the area and integrate this information with borehole data to develop a three-dimensional model of the moraine. Interpretations of the data have possible applications in environmental issues related to groundwater, waste disposal and resource management.

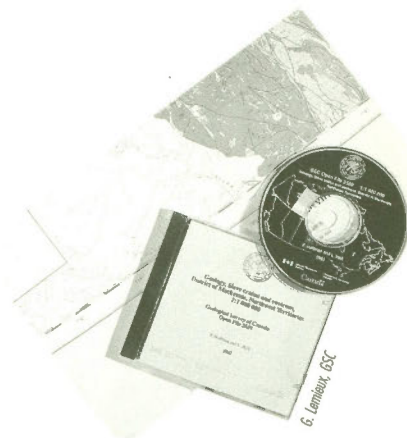
These projects will all continue in 1994-95, and a new project in the Magdalen Basin in the Maritimes will start up.

For more information about NATMAP, please contact:

Mike Cherry
NATMAP Coordinator
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Fax: (613) 992-5051
Internet: mcherry@gsc.emr.ca

Scaffloor Minerals Program

Studies of the formation of massive sulphide deposits located on submarine spreading ridges and hydrothermally active basins have important implications for the exploration for ancient sulphide deposits such as Kidd Creek and Noranda. During the past year, two significant research cruises were carried out with GSC participation. One, aboard the German research vessel *Sonne* to document seafloor deposits in the Taber-Feni Arc area east of Papua New Guinea, received funding from the University of Mississippi Marine Minerals Technical Centre. The other, off Canada's west coast, brought together a team of scientists from the GSC, the U.S. National Oceanic and Atmospheric Administration (NOAA), Fisheries and Oceans Canada (DFO) and Canadian universities, to study Juan de Fuca ridge. This work complements that being carried out in Atlantic Canada for occurrences of offshore gold and other placer minerals, sand and gravel.



NATMAP PRODUCTS

As a testament to their success in achieving the NATMAP goal of increasing the level of geoscience mapping in Canada, NATMAP projects have released 20 new maps in paper format and two CD-ROMS since their inception in 1991. This significant level of map production has been facilitated by the use of digital GIS technology. NATMAP CD ROM releases are described on page 23.

ENERGY

The energy supplies of any country are one of its most precious national resources and are absolutely vital to its future. The Geological Survey of Canada directs its national program of energy-related research towards providing the knowledge infrastructure necessary for the long-term management of these resources and for exploration and development.

Resource Assessments

As part of its national mandate, the GSC carries out assessments of undiscovered petroleum and natural gas resources in Canada. This program has several goals: to ensure Canada's long-term security of supply is accurately appraised, to facilitate export planning and permitting, and to assist land-use planning where future resource development should be considered, for example linked to the establishment of national parks. Recent efforts have focussed on assessments of natural gas resources in Alberta and British Columbia: in the Foothills area, in Triassic strata, and in Cretaceous Mannville strata (the latter including Saskatchewan). Another milestone was the compilation of a summary chart of resources for all Canadian basins containing significant discoveries. For the future,

a Canada-wide petroleum resource assessment is scheduled to replace the last national study published in 1984.

Basin Modelling

As part of the Industrial Partners Program, GSC and Platte River Associates (PRA), a world leader in petroleum basin modelling software, combined forces to field test, evaluate and apply early versions of PRA's 2-D program that models hydrocarbon generation, migration and accumulation in a compacting sedimentary sequence. Test applications of this software are underway in the Jeanne d'Arc Basin, offshore Newfoundland, where it is aiding a project that examines the charging and degradation history of pools in the Terra Nova to Ben Nevis Area. In the Sable Basin, offshore Nova Scotia, test applications are helping develop a regional understanding of overpressure distribution. Such case studies contribute to the recognition of knowledge gaps, software inadequacies and implementation problems.

New Hydrocarbon Project

Industry and GSC are working together to develop a stratigraphic framework for the oldest sedimentary

strata (Lower Paleozoic) of the Western Canada Sedimentary Basin. This is a virtually unexplored frontier, and these strata may have significant effects on the distribution and character of higher, more traditional hydrocarbon target units. The project has attracted 13 industrial partners who are contributing \$80 000 cash and about \$100 000 of in-kind support, and is being funded under GSC's Industrial Partners Program.

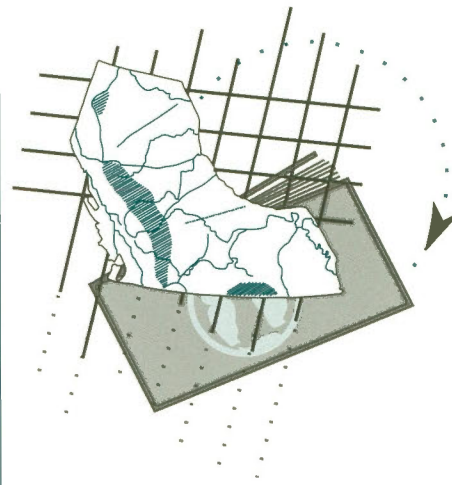
Geological Atlas of the Northern Canadian Mainland Sedimentary Basin

The GSC and NWT Department of Energy, Mines and Petroleum Resources entered into a partnership to undertake joint studies in NWT. A product of this work will be a comprehensive geological and geophysical atlas covering a large region of the northern Canadian mainland centred on the "Mackenzie Corridor". Through large-scale maps and cross sections, the atlas will help exploration companies place the geology of existing and potential areas of mineral and petroleum exploration in a clear regional context. It will also provide an inventory

for non-renewable resources across the northern mainland of Canada of use to planners and policy makers.

Studying the Environmental Impact of Coal Combustion

Through its National Coal Inventory, the GSC initiated work funded by Alberta utilities, GSC's Industrial Partners Program and the Panel on Energy Research and Development (PERD), to quantify the dispersion of trace and other elements into the environment through coal combustion. This study, the first of its kind in Canada, focusses on three power plants located near Canada's largest coal strip-mine west of Edmonton, as well as power plants in Nova Scotia. It will provide objective information on the dispersion of potentially hazardous elements into the environment that will help focus R&D on mitigating, cleaning and utilization technologies (to be conducted by CANMET), and provide information for the development of environmental regulations. Similar projects, to be conducted in cooperation with utilities in Saskatchewan and southern Alberta, CANMET and Environment Canada, are under discussion.



GEOLOGICAL ATLAS OF THE WESTERN CANADA SEDIMENTARY BASIN

A milestone in geoscience synthesis was reached in the spring of 1994 with the release of this atlas. Sponsored by Alberta Energy, the Alberta Research Council (through the Alberta Geological Survey), the Canadian Society of Petroleum Geologists and the GSC, the "Geological Atlas of the Western Canada Sedimentary Basin" is a major achievement representing seven years of compilation and effort from a mostly volunteer production team (including scientists from industry, academia and federal and provincial government agencies, consultants and a few retirees). The atlas contains 35 chapters varying from regional themes to specific stratigraphic intervals. GSC is proud to have been involved in the production of this remarkable project. The atlas is available from the Canadian Society of Petroleum Geologists, the Alberta Research Council and GSC's Institute of Sedimentary and Petroleum Geology. (510 pages, \$185 Cdn.)

Focus on: Industrial Partners Program

The Industrial Partners Program (IPP) is designed to enable new cost-shared projects between Canadian industry and the Geological Survey. Its objectives are to build stronger links between GSC and industry and to ensure that GSC expertise is directly applied to problems of mutual interest.

The program has given GSC the opportunity to carry out research in cooperation with industry on a number of scientific and technological initiatives. Through these jointly funded ventures, advances in exploration geoscience have been realized in the fields of exploration geochemistry, borehole geophysics, analytical chemistry and metallogenic studies of a number of deposits.

Cooperative research has also resulted in technology transfers to the private sector, for example, in borehole instrumentation, water well sampling equipment and new analytical equipment and techniques.

During 1993-94, 75 companies partnered with GSC scientists in 52 IPP projects. Some highlights include:

- **Competitive Edge for Canadian Industry**

Sander Geophysics Ltd. and GSC are working with a variety of other partners from the oil industry, universities, Institute of Aerospace Research and National Research Council to develop a cost-effective airborne gravity survey system. The development of this improved

system, combined with magnetic/EM/radiometric configurations, will give Canadian industry a competitive edge in North American and particularly overseas markets, where the demand for such a system is high.

- **Commercialization of Deep-Tow Refraction System**

The commercialization of a deep-towed seismic refraction surveying system was carried out with E.B.A. Ltd. The system, designed by GSC staff to detect shallow ice-bonded permafrost beneath the seafloor of the Beaufort Sea, measures the seismic velocities of sub-seabottom sediments in a continuous mode at marine survey tow speeds. It can be used for engineering surveys of the seafloor to depths of 100 m as part of a multiparameter engineering geophysics survey program. The first commercial application of the deep-towed system is planned for the summer of 1995.

- **Crude Oil Biodegradation**

Several oil and gas exploration and production companies together with GSC are investigating the processes that have severely biodegraded some crude oil pools in the Jeanne d'Arc Basin, offshore Newfoundland. The development of models that explain the charging and degradation history of pools in the basin will assist the assessment of the risk that further accumulations in similar settings will be degraded. The study will also provide for

more accurate resource assessments in the basin, allowing basin-wide estimates to be discounted by degraded volumes.

- **Seismic Exploration Technique**

GSC and Falconbridge Ltd. worked together to evaluate the performance of multi-component vertical seismic profiling as a seismic acquisition technique to image steeply dipping geological structures in the crystalline crust. The technique provides a new viable imaging technique when integrated with structural geology, surface seismic, physical rock property and borehole geophysical studies, and will no doubt become a valuable exploration tool for identifying and following specific structures at depth.

- **Borehole Exploration Technology**

GSC and IFG Corporation worked together closely to commercialize an experimental model of a Spectral Gamma Gamma borehole (SGG) logging tool, developed in-house by GSC. The SGG uses gamma rays to determine the density of rocks surrounding a borehole. SGG logging also provides information on the concentration of heavy metals and, therefore, offers potential as an *in situ* assay technique.

- **Assessing Natural Sources of Mercury**

A project with Ontario Hydro helped identify natural sources of mercury in the environment. Elevated levels of mercury in fish and sediment of certain lakes in central Ontario have been attributed primarily to airborne pollution from

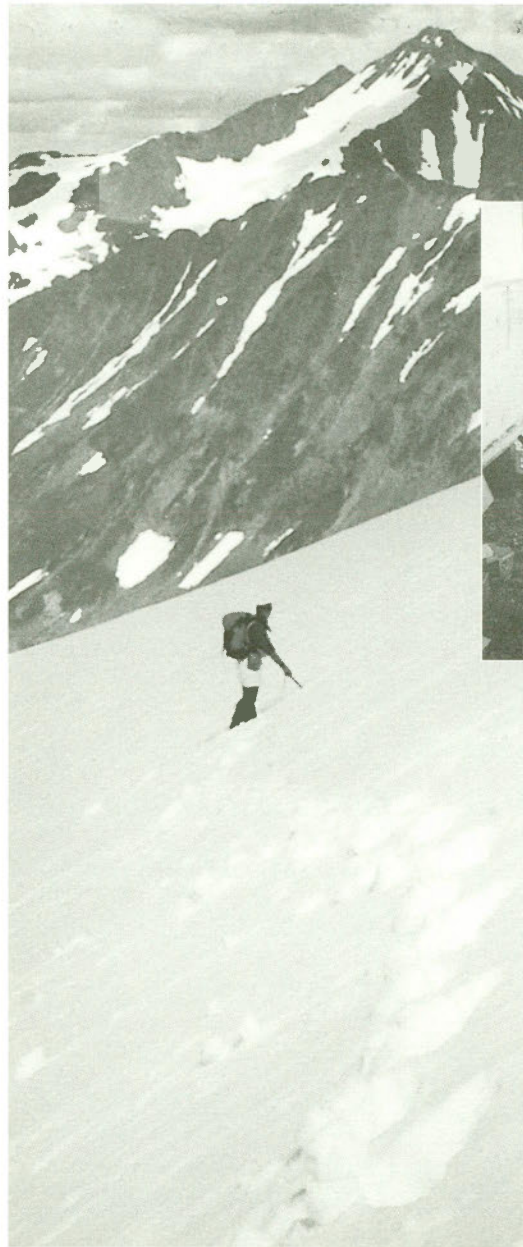
fossil fuel combustion in the Great Lakes region. Detailed studies of the geochemistry of lake sediments and glacial till in these areas demonstrated the significance of the natural contribution of mercury to these lakes.

- **Remote Weather Autostations**

GSC and Campbell Scientific Canada are working to investigate problems of recording meteorological variables in severe environments. Sophisticated equipment has been installed on two ice caps in the Canadian Arctic Islands and one in the Russian Arctic. Under such severe weather conditions, it has become clear that substantial modifications must be made to equipment to withstand icing in both winter and summer. These modifications are now being tested. Exposure of the equipment in Russia could give Campbell Scientific a competitive edge in a research field that is attracting an increasing amount of scientific interest in Europe, the U.S.A. and Japan.

These are just a few of the exciting results coming out of partnerships under the Industrial Partners Program. If you would like more information or a brochure on how to apply to the program, please contact:

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601 Booth St., Ottawa, Ontario, K1A 0E8
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Internet: dharry@gsc.emr.ca



P. Danahy, Lac Minerals



Geological Map for Mineral Exploration: GSC and Lac Minerals worked together in the Red Mountain area, a remote part of northwestern British Columbia, where Lac has a gold property with large potential. Lac needed modern geological maps of the area, and worked with GSC to map the geology in detail as a guide for future exploration for other deposits. The resulting map was released as a GSC Open File and is popular with exploration companies working in the region.

Geoscience data and methods provide a fundamental baseline for environmental change studies and are vital to local issues of land stability, toxic waste disposal, and polluted water and air. They form the basis for rational decisions on competing land uses.

Greater Toronto Area Hydrogeology Study

The Oak Ridges Moraine is a major aquifer complex and one of the most heavily used groundwater sources in Canada, supplying much of the potable water for the Greater Toronto Area. As part of a new national Hydrogeology Program, the GSC began a four-year regional pilot study of the moraine to understand the interior structure and controls on groundwater flow. The complex geology of the moraine requires new subsurface investigations using environmental mapping techniques developed at GSC. These techniques allow evaluation of promising, safer, deep aquifers that have not been adequately explored. There is pressure to expand use of this resource, but first the extent of water-bearing sediments and distribution of recharge must be better understood. The study relies on cooperation from provincial government ministries, planning and engineering departments of all the Greater Toronto Area regional municipalities, several consulting firms and universities.

Pilot Project in Quebec's Great Whale Region

As part of the environmental impact assessment of the Great Whale region where a major hydroelectric development is planned, GSC carried out a multidisciplinary pilot project to measure variations in mercury content and other heavy metals in the region's surficial materials and soil. Analysis of soil profiles shows that biogeochemical recycling over the past few millennia has played an important role as anthropogenic contamination over the last century. Permafrost and terrain stability have also been assessed and mapped. The results will be used in determining the impact of geological and geochemical processes with respect to public health and natural hazards.

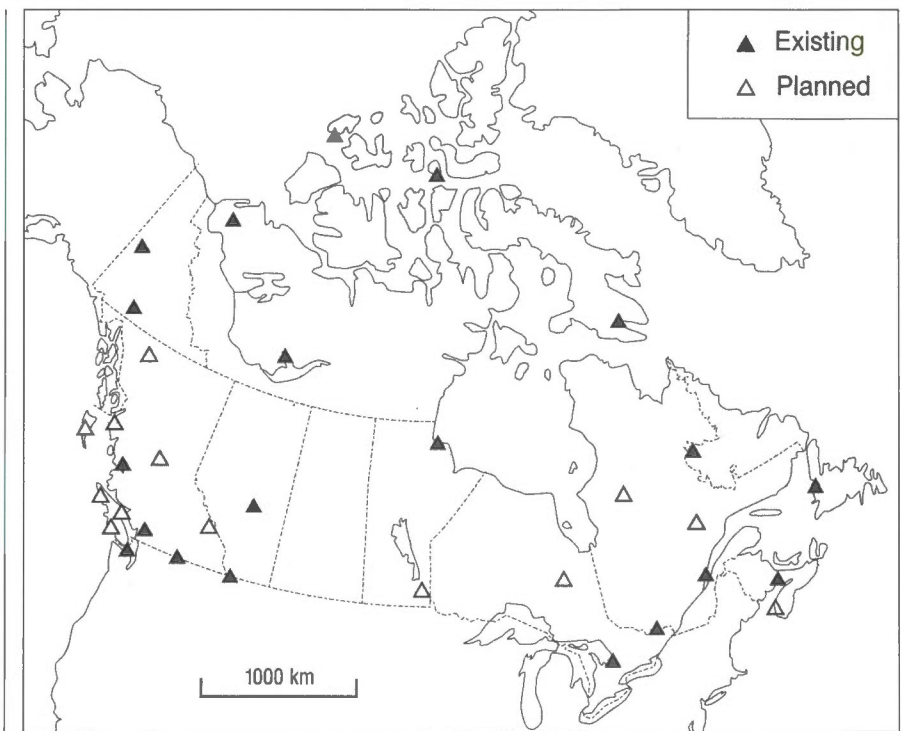
Megathrust Earthquake Hazard on the West Coast

The aftermath of a megathrust earthquake on the west coast of North America would be devastating in terms of human tragedy and economics — \$30 billion is the estimated cost of damages. GSC studies have shown that southwestern British Columbia is a prime area for a megathrust event. Seismic, deformational, geothermal and other studies have been used to estimate the location of the locked portion of the subduction thrust fault off the west coast of Canada. Citing the

unique expertise of GSC scientists, the U.S. Geological Survey has provided funding for GSC to carry out a program on the megathrust earthquake potential off the coast of Washington and Oregon. The results of this research will have a large impact on emergency preparedness planning for British Columbia and the northwestern U.S. Furthermore, it is hoped that the work will show where we are in the 300 to 600 year cycle the geological record shows for megathrust events in this region.

Heavy Metals in the Environment

GSC has been increasingly called upon to provide advice on domestic and international initiatives related to toxic substances in the environment. Some examples include the assessment of "Priority Substances" under the *Canadian Environmental Protection Act* and input to both the United Nations program on Long-Range Transboundary Air Pollution and the OECD program on Cooperative Risk Reduction. Many of the substances of concern, most particularly heavy metals, are naturally occurring. Geoscientific input is essential to assess relative contributions from natural and industrial sources, and as well to understand the speciation and availability of these substances in the environment.



NATIONAL EARTHQUAKE MONITORING NETWORK

The GSC has the sole responsibility for monitoring and reporting earthquake activity throughout Canada. This task requires a network of seismometers across the country to detect, locate and report upon seismic activity. The GSC has just completed a five-year project to completely modernize the national seismograph network. Data from instruments across Canada are now sent immediately, in most cases by satellite, to GSC seismology centres in British Columbia and Ottawa. There the data are analyzed automatically and the results reviewed by seismologists.

The new network provides almost immediate (within minutes) information on earthquakes anywhere in Canada. For larger events, emergency planning organisations are notified, media announcements issued, and information provided to the public. Over the longer term, the network provides data for research that will provide a better understanding of the causes and results of earthquakes in Canada. The information is also used to revise the earthquake resistance provision of the National Building Code and in the design of strategic installations such as power plants. The network also provides information to international agencies for studies of global earthquake activity.

The new network benefits from a number of close partnerships. For example, power utilities in Quebec, Ontario and British Columbia fund the operation of many sites; while at all Arctic locations, satellite communications facilities are shared with other government agencies.

Since its founding in 1842, the Geological Survey has been recognized for its innovation in creating new methods and technology or adapting existing technology to the geoscientific problem at hand. Technology transfers to industry for commercial development have met with great success.

New Technology Looks at Subsurface of Mining Camps

INCO, Falconbridge (Sudbury) and GSC conducted innovative high resolution seismic and electromagnetism work that resulted in new technology for examining the subsurface around mining camps. This will maximize the efficiency of exploration and therefore assist in the extension of the lifetime of existing mines and adjacent communities. Better targetting capabilities will also reduce environmental disruption in and around mining camps.

Marine ElectroMagnetic (MEM) System

This new instrument was developed to determine the apparent *in situ* porosity of the seafloor sediments in a profiling operation. Towed along the seafloor, it measures the electrical conductivity of the top 20 m sub-seafloor sediments. These measurements, which are used to calculate the apparent porosity, indicate the texture of the seafloor (sand or finer-grained materials) — information required by geotechnical engineers and marine sedimentologists. After successful testing, the technology is now being transferred to industry. As part of an Industrial Partners Program project, a Canadian survey company carried out market research and participated in recent surveys. Requests for contract proposals have been received from the U.S. Army Corps of Engineers and the Netherlands Geological Survey. Companies involved in North Sea pipeline work, Southeast Asia cable routes, and harbour dredging have asked for more information on the MEM system.

GEOSCIENCE LABORATORIES

CORK

An instrument which, in effect, is a deep sea borehole geophysical observatory was the result of cooperation between the GSC and the Ocean Drilling Program. Three have been deployed so far: two on the Juan de Fuca Ridge off Canada's west coast and the third off Barbados. CORK monitors formation fluid pressure and temperature and allows for formation fluid sampling — information important for monitoring the subduction earthquake cycles.

New Diamond Exploration Technique

GSC geophysicists have developed an automated technique for the identification of magnetic anomalies related to possible kimberlite pipes. By narrowing down the number of possible targets, this technique has potential for significant time and cost savings in diamond exploration.

Delta-Lab



The isotopic geochemistry laboratory of GSC's Quebec Geoscience Centre analyzes stable isotopes of hydrogen, carbon, nitrogen and sulphur using PRISM-VG, Isotech, SIRA-12, GC-COMBUSTION-Prism, auto-water for oxygen and extraction lines for water, carbonates, sulphides, sulphates and organic matter.

With this equipment, the laboratory is able to cover the entire range of stable isotopic tracers applied to hydrogeological, environmental, metallogenic, diagenetic and sedimentological studies by analyzing the isotopes of water, reagent hosts and dissolved components.

For further information, contact:

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2700, rue Einstein; C.P. 7500
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G1V 4C7
Telephone: (418) 654-2634
Fax: (418) 654-2615
Internet: savard@gsc.emr.ca

Geochronology Laboratory

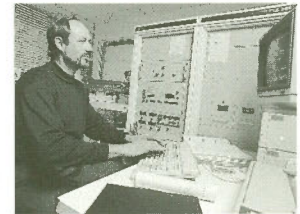
GSC's Geochronology Laboratory specializes in age dating and isotope microanalysis using U-Pb, Sm-Nd, Rb-Sr and Ar-Ar radiogenic systems. It is especially known for its development of innovative age-dating techniques to resolve new problems in geological mapping and timing of tectonic and mineralizing events. Advice from laboratory staff and use of its state-of-the-art facilities are available to clients in Canada and abroad.

Plans are underway for the installation of a sensitive high resolution ion microprobe in the summer of 1995.

One of only a half dozen in the world, the ion

microprobe will broaden the spectrum of geoscience questions that the GSC can address. For more information about the services available and costs, contact:

Geochronology Laboratory
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario
K1A 0E8
Telephone: (613) 995-8785
Fax: (613) 995-7322
Internet: parrish@gsc.emr.ca



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INFORMATION

The Geological Survey of Canada has extensive national geoscientific databases and is a major scientific publisher. Internationally respected research, combined with advanced in-house cartographic capability and digital systems, has made the GSC a world leader in the provision of geoscientific information. This information is available through direct sales, data exchanges, training courses and workshops.

Digitizing Canada's Geoscience

Through the innovative use of digital field systems and GIS (Geographic Information Systems), the GSC is providing quicker access to geoscience information and developing prototypes for digital standards. Through links with the provinces and territories under programs such as NATMAP and the Mineral Development Agreements, GSC is coordinating the construction of a digital geological framework of Canada's landmass and adjacent oceans. An excellent example is a new three-year cooperative project with the Ontario Geological Survey to compile a digital geoscience database over a selected portion of the northeastern mining belt in Ontario and develop geographic information technology to assist geological mapping and exploration activities.

The project is funded under the Canada/Ontario Mineral Development Agreement and involves Noranda and Falconbridge. Both companies have contributed \$400 000 of proprietary data to the project in exchange for exclusive access to the results for a limited time.

National Digital Geoscience Data Library

In 1993, the petroleum industry donated more than \$100M worth of digital seismic data to the GSC on the condition that it be maintained and made available for research purposes. GSC's Atlantic Geoscience Centre in Dartmouth, Nova Scotia, has now established a public viewing, processing and interpretation facility comprising state-of-the-art Computer Assisted Exploration (CAEX) workstations and software to fully exploit the potential of the data. This new facility provides unique research capabilities rarely found outside the petroleum industry. Users can process raw multi-channel seismic data to optimize display of structural and stratigraphic information and to efficiently integrate geological and geophysical data in the production of innovative maps and interpretations. It is also fostering non-traditional uses of the technology such as processing and interpretation of high-resolution single-channel data to solve environmental problems.

Geophysical Data and Services

NEW CD-ROM RELEASES ARE A FIRST FOR GSC

GSC passed a milestone in information delivery this past year with the release of its first CD-ROM compilations of geoscience information. These are designed to meet the public demand for up-to-date, accurate digital geoscientific data. The CD-ROM format gives GSC clients more efficient access to important new scientific results and facilitates the application of more effective digital methodology by users.

- **Preliminary release: Selected geoscience data for the NATMAP Shield Margin Project area, Manitoba and Saskatchewan.**

H.J. Broome, D. Viljoen, and the NATMAP Digital Working Group, 1993. GSC Open File 2743 (compact disc). \$150.00

GSC's Shield Margin NATMAP Project focussed on the Flin Flon-Snow Lake-Hanson Lake Belt and its sub-Phanerozoic continuation in Manitoba and Saskatchewan. The CD-ROM is a tangible demonstration of the progress made towards achieving one of the project's major goals — the development of a comprehensive, integrated digital geoscience database. The CD-ROM's datasets, representing the results of intensive studies by many geoscientists from federal and provincial governments, academia and the mineral exploration industry, include bedrock geology, surficial geology, hydrographic data, gravity imagery, magnetic imagery, radiometric data, mineral deposit occurrence data, geochronological data, Landsat data and synthetic aperture radar (SAR) data. They are provided in common interchange formats compatible with both a commercial data visualization package and GIS systems.

- **Geology, Slave craton and environs, District of Mackenzie, Northwest Territories (1:1 000 000).** P. Hoffman and L. Hall, 1993. GSC Open File 2559 (compact disc). \$60.00

This CD-ROM contains a geological compilation map of the Slave craton and its environs. It covers the areas between Bathurst Inlet, Coronation Gulf, Great Bear Lake, Great Slave Lake and the territorial border (60°N). This region includes the main diamond play and an important exploration area for other mineral commodities in the Northwest Territories. The CD-ROM offers users of geoscientific information (e.g. mineral exploration companies, land-use planners) the opportunity to superimpose and integrate different types of datasets with the geological map on their own computer. It provides data in several internationally accepted formats and is designed to be accessible to both large workstation computers and desktop systems.

Two more CD-ROM products are nearing completion:

- **Digital Cordilleran Geoscience Compilation:** As part of the Decade of North American Geology Project, GSC prepared a new synthesis of the geology of Canada's vast and geologically complex Cordillera. A paper version was published as the "Tectonic Assemblage Map of the Cordillera". The new CD-ROM product, funded under the Canada/British Columbia Mineral Development Agreement, contains, at the 1:1 million scale, the spatial and geoscience data of this synthesis.
- **Generalized Geological Maps of the World and Linked Databases:** A multi-product line that will be available as a CD-ROM folio collection or as individual paper and digital products on broad thematic topics such as generalized geology of the world, global distribution of sediment-hosted stratiform copper deposits and occurrences, and hydrothermal activity and associated mineral deposits of the seafloor.

The Geophysical Data Centre provides user access to national aeromagnetic and gravity databases and supplies digital data, data processing and plotting services.

The National Aeromagnetic Database contains more than 11 000 000 line kilometres of regional total field survey data and high resolution detailed surveys. The aeromagnetic data have been levelled to a common datum, and levelled profile and gridded data are now available for eight provinces and the Northwest Territories. The National Gravity Database contains 650 000 gravity observations and 5500 gravity control stations. Data are provided in a variety of formats in consultation with clients. Contact:

*Geophysical Data Centre
Geological Survey of Canada
1 Observatory Crescent
Ottawa, Ontario
K1A 0Y3
Telephone: (613) 995-5326
Fax: (613) 992-2787
Internet: info@gsc.emr.ca*

NEW INFORMATION SERVICES

GEOSCAN on CAN/OLE

The bibliographic database GEOSCAN is now available on the Canada Institute for Scientific and Technical Information On-Line Enquiry Service (CAN/OLE).

GEOSCAN is a comprehensive reference to geoscience literature about the Canadian landmass and offshore regions. It contains over 190 000 bibliographic records including serials, books, theses, maps, open files and mineral assessment reports. GEOSCAN is produced cooperatively by 15 federal, provincial, academic and professional geoscience organizations across Canada.

Charges for searching GEOSCAN on CAN/OLE are \$60 per hour and \$40 per reference online.

To become a CAN/OLE user, contact:

Electronic Products and Services - CAN/OLE
Canada Institute for Scientific and
Technical Information
Building M-55, Montreal Road
Ottawa, Ontario K1A 0S2
Telephone: (613) 993-1210 (collect)
Fax: (613) 952-8244 (Attn: CAN/OLE)
Internet: cisti.ole@nrc.ca

For information on GEOSCAN, contact:

Canadian Geoscience Information Centre
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8
Telephone: (613) 996-3919
Fax: (613) 943-8742
Internet: library@gsc.emr.ca

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Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8
Telephone: (613) 996-3919
Fax: (613) 943-8742
Internet: library@gsc.emr.ca

Client Feedback Leads to New GSC Service in Toronto

Three days of consultation with Toronto clients, mainly in the mining industry, helped the GSC define the services it should provide in the Toronto area. Clients were unanimous in their support for a GSC service in Toronto for the delivery of GSC information services and products. Negotiations between GSC and the Ontario Geological Survey are underway to work out a sharing of space in their Toronto information centre.

Prize-Winning Maps

GSC leadership in digital geological mapmaking was recognized at the GIS '94 conference in Vancouver. A new GSC map of the Spatsizi River area in northwestern B.C., won first prize in the prestigious Environmental Systems Research (ESRI) mapping contest for Canada (reference: *Geology, Spatsizi River, British Columbia (104H)*, C.A. Evenchick, D.J. Thorkelson, Open File 2719, 1 map: colour, digital, \$15.00). The GSC "*Circumpolar Map of Quaternary Deposits of the Arctic*" received top honours at the annual conference of the International Cartographic Association, which is a

premier venue for the presentation of world-wide developments in cartography. The map is a unique compilation of Canadian and Russian geological Quaternary data compiled by GSC scientists in collaboration with their Russian peers (reference: GSC Map 1818A, \$10 Canada, \$12 outside Canada).

Landmark Book on Dinoflagellates

In August 1993, the GSC celebrated the publication of the first comprehensive natural classification of living and fossil dinoflagellates. Dinoflagellates are planktonic micro-organisms that are geologically important as fossil indices of geologic age and environmental history. The 350-page book was authored by a team of geologists and biologists from government, academia and industry. Reviews indicate that it will become a standard in its field for many years to come (reference: *A Classification of Living and Fossil Dinoflagellates* by R.A. Fensome, F.J.R. Taylor, G.L. Norris, W.A.S. Sarjeant, D.I. Wharton and G.L. Williams. Micropaleontology Press, American Museum of Natural History, 350 p., US\$90).

Geophysical Data and Services

Earthquake and Seismic Hazard Information

Rapid information on felt earthquakes in Canada and monthly and annual reports of recent activity are available. Estimates of seismic hazard can be generated for any part of the country. Many specialized datasets are available for larger earthquakes in Canada, and information can be provided on earthquake activity in other parts of the world. Contact:

(for eastern Canada)

Geophysics Division
Geological Survey of Canada
1 Observatory Crescent
Ottawa, Ontario
K1A 0Y3

Telephone: (613) 995-5548

Fax: (613) 992-8836

Internet: info@seismo.emr.ca

(for western Canada)

Pacific Geoscience Centre
Geological Survey of Canada
9860 West Saanich Road,
P.O. Box 6000
Sidney, B.C.

V8L 4B2

Telephone: (604) 363-6500

Fax: (604) 363-6739

Focus on Outreach: Geoscience for the Next Generation

The Geological Survey of Canada is committed to increasing Canadians' awareness of the earth sciences. Since the 1920s it has been a respected training ground for the Canadian geoscience community through the summer employment of students to work as field and laboratory assistants for GSC scientists.

The GSC has traditionally produced information materials aimed at stimulating the interest of young people in the earth sciences. For example, GSC rock and mineral kits have been available for educational purposes

since 1874. Current communications efforts continue to have a strong component aimed at young audiences. Individually, GSC scientists give a lot of their time to work directly with young people, whether it be as a speaker at a school or a judge at a science fair.



B. Sawyer, GSC

An open house at GSC's Pacific Geoscience Centre in Sidney, British Columbia, in September 1993 attracted 8000 visitors, including over 60 guided school tours. The event was co-hosted with the Institute of Ocean Sciences which shares space and facilities. Visitors toured laboratories and research vessels, and learned about GSC's work through a series of talks and displays on marine research, earthquakes and climatic change.

How to connect with GSC outreach activities:

- **Book a speaker**

GSC scientists are available through the "Innovators in the Schools Program" (national), "Rent a Scientist" (Nova Scotia), the Calgary Science Hotline, "Scientists in the Schools" (British Columbia). Speakers in the Ottawa area can be booked through the GSC Communications Office (see below).

- **Visit a science fair**

Many GSC scientists act as judges and mentors at these events at the local and regional levels.

- **Tour a GSC office**

(see Directory on page 34 for general information numbers to inquire about availability). Logan Hall, GSC's museum at the Ottawa headquarters, is open for self-guided tours during business hours. Group tours may be booked through the Communications Office.

- **Go where the rockhounds go**

GSC takes part in many rock and mineral shows each year, most recently in Montreal, Ottawa, Bancroft, Sudbury, Calgary and Vancouver.

- **Celebrate National Science and Technology Week each October**

GSC scientists give their time to help build awareness of the geosciences through a range of activities across the country, and GSC facilities in Ottawa and Calgary offer special tours on-site activities.

- **Visit a museum**

GSC scientists have worked with many major Canadian museums to develop displays that enhance appreciation of the geosciences.

For a listing of educational materials available from the Geological Survey of Canada, please contact:

Communications Office
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8
Telephone: (613) 995-3084
Fax: (613) 996-8059
Internet: vodden@gsc.emr.ca

Geophysical Data and Services

G eomagnetism Information

Information on variations of the Earth's magnetic field is available from the Canadian network of 13 magnetic observatories. Standard datasets include 5-second data, 1-second data, and annual mean values. Data are available in near real-time through INTERMAG-NET. Information on the strength and direction of the magnetic field, and its secular variation, can be provided via a computer bulletin board. A software package to compute field values is also available. Short- and medium-term forecasts of magnetic activity are produced regularly. The short-term forecasts are available via computer bulletin board. Contact:

*Geomagnetism
Geological Survey of Canada
1 Observatory Crescent
Ottawa, Ontario
K1A 0Y3
Tel: (613) 837-4561
Fax: (613) 824-9803
Internet: coles@geolab.emr.ca*

Charges apply to some products



Mineral Resource Assessment of the Neoproterozoic Franklin Igneous Events of Arctic Canada: Comparison with the Permo-Triassic Noril'sk-Talnakh Ni-Cu-PGE Deposits of Russia

by C.W. Jefferson, L.J. Hulbert, R.H. Rainbird, G.E.M. Hall, D.C. Gregoire and L.I. Grinenko

As part of the Mineral and Energy Resource Assessment of the proposed Tuktoyaktuk National Park in NWT, comprehensive data on the potential for magmatic nickel-copper deposits were collected in the region. This report concludes that many of the attributes characteristic of the setting of the world-class Noril'sk deposits of Russia are present on northern Victoria Island (but not in the park area). 48 pages. (GSC Open File 2789). \$15.00 for diskette. Paper copy/available from Ashley Reproductions.*

Assessment of Mineral and Energy Resource Potential in the Laughland Lake Terrestrial Area and Wager Bay Marine Area

by C.W. Jefferson, F.W. Chandler, L.J. Hulbert, J.E.M. Smith, K. Fitzhenry, and K. Powis

This report describes the results of a resource assessment of an area which includes part of the proposed Wager Bay National Park in NWT. It concluded that much of the region has low to moderate mineral potential, but rocks of the Prince Albert Group in the Laughlin Lake area and outside of the proposed park boundary have a moderate to high potential for several types of mineral deposits including gold, nickel-copper and carving stone. 58 pages. (GSC Open File 2659).*

Triassic Gas Resources of the Western Canada Sedimentary Basin, Interior Plains

by T.D. Bird, J.E. Barclay, R.I. Campbell, P.J. Lee, R.R. Waghmare, S.M. Dallaire and R.F. Conn

Significant hydrocarbon discoveries in Triassic-age strata of western Canada in recent years have led to GSC involvement in an assessment of potential gas resources. Play concepts are defined and each evaluated for its gas and economic potential. 100p. (GSC Open File 2911). \$25.00. *A GSC Bulletin of the same name will be published in late 1994.*

Géologie des formations superficielles, région de la Petite rivière de la Baleine, Québec nordique

by M. Parent and S.J. Paradis

This report covers the pilot project area which constitutes the initial phase of the Great Whale project. It provides basic data required for more in-depth analysis of current geological and geochemical processes. 48 p. plus 2 1:100 000 scale maps (GSC Open File 2643).*

Sedimentary Cover of the Craton in Canada

edited by D.F. Stott and J.D. Aitken

The fifth of nine volumes to be published in the "Geology of Canada"/Decade of North American Geology series, this volume gives a comprehensive description of the geology of the sedimentary rocks on the Canadian craton. 826p. (Geology of Canada No. 5). \$70.00 in Canada, \$91.00 outside Canada.

Studies of Rare Metal Deposits in the Northwest Territories

edited by W.D. Sinclair and D.G. Richardson

During the 1980s and early 1990s, significant exploration was conducted in Canada for deposits of the rare metals, including niobium, tantalum, zirconium, beryllium and, in particular, yttrium and rare earth elements. This volume gives results of research on such deposits, conducted in large part under the Canada-NWT Mineral Development Subsidiary Agreement. 96 pages. (GSC Bulletin 475). \$12 in Canada, \$15.60 outside Canada.

Structural Analysis of Lode Gold Deposits in Deformed Terranes

by F. Robert, K.H. Poulsen and B. Dube

This volume contains notes used for a short course presented at the 1994 GSC Minerals Colloquium on the structural analysis of ore deposits. It examines the structural factors controlling the geometry of deposits and orebodies and how they can be used in exploration and mining. 140 pages. (GSC Open File 2850).*

Aerial Video Survey of the Southeastern Hudson Bay Coastline

by Y. Michaud and D. Frobel

This report with video provides a visual record of the characteristics of the southeastern Hudson Bay coastline. 35 p. plus 6 videocassettes (GSC Open File 2895). Ordering information available from Dave Frobel (902) 426-7736.

A Sampler of GSC Publications

Distribution and Character of Kimberlite Indicator Minerals in Glacial Sediments, C14 and Diamond Lake Kimberlite Pipes, Kirkland Lake, Ontario

by S.A. Averill and M.B. McClenaghan

This report is one of the first to show how indicator minerals in glacial sediments can be used to find drift-covered kimberlite pipes. Previously, companies exploring in Canada's glaciated terrain had to rely on data from nonglaciated countries. In Canada, secrecy within the diamond industry has prevented publication of any exploration methods using the tracing of minerals in glacial sediments. 48 p. (GSC Open File 2819). \$46.00 *

Formation and Failure of Natural Dams in the Canadian Cordillera

by J. Clague and S.G. Evans

This volume describes historical natural-dam failures in the Cordillera of western Canada, where many damaging floods have resulted from the sudden failure of landslide, moraine and glacier dams. Methods of identifying and assessing potentially hazardous natural dams are also discussed. 35p. (GSC Bulletin 464). \$6.00 in Canada, \$7.80 outside Canada.

Quaternary Geology and Drift Prospecting, Beardmore-Geraldton Area, Ontario

by L.H. Thorleifson and F.J. Kristjansson

The Beardmore-Geraldton area has a well-developed infrastructure and an excellent potential for further discoveries of gold and other metallic minerals.

This report summarizes for the explorationist surficial geological surveys carried out as a cooperative Mineral Development Agreement project with the Ontario Geological Survey. 146p. + 1 map, scale 1:100 000 (GSC Memoir 435). \$23.00 in Canada, \$29.90 outside Canada.

Seismic Markers and Stratigraphic Picks in Scotian Basin Wells

by B.C. Maclean and J.A. Wade

This publication includes lithostratigraphy on 139 wells in the Scotian Basin as well as ties between these wells and some 300 000 km of industry seismic data. Seismic horizon and fault interpretation, synthetic seismic traces, biostratigraphic data of most wells, play type, and significant hydrocarbon occurrences are also displayed on the two-page, 11" x 17" format. 276 pages. Individuals-Canada: \$120, outside Canada \$155. Institutions/libraries-Canada: \$175, outside Canada \$220. Order from Jennifer Bates (902) 426-4386, fax: (902)426-4848, e-mail: agc@agcrr.bio.ns.ca, gopher site: agcgopher.bio.ns.ca.

Geology of the Rocky Mountain Foothills and Kananaskis Country

by M.E. McMechan

Kananaskis Country is a large and popular provincial park in Alberta, and this map will be of interest to anyone with a general interest in the area's geology. For geoscience professionals, the map is an essential tool for understanding the gas-bearing rocks within the complexly folded Foothills adjacent to the park. Scale 1:100 000 (GSC Open File 2642). \$15.00

ORDERING INFORMATION

Publications may be ordered from the GSC Bookstore in Ottawa or from our regional offices in Sainte-Foy, Calgary and Vancouver (see page 34 for addresses). Prepayment is required by cheque or money order made out to the Receiver General of Canada. VISA and Mastercard are accepted.

All prices listed are in Canadian dollars.

** Ordering information for these items available from Ashley Reproductions (613) 235-2115*

The Geological Survey of Canada's long tradition of leadership and advocacy of geoscience and of promoting the Canadian perspective on the international scene has earned it a sterling reputation with the global geoscience community. As a result of this international involvement, tremendous benefits have accrued that have strengthened the status of Canadian geoscience. For example:

- By participating in bilateral and multi-national scientific collaborative programs, we have been able to enhance the quality of the geoscience information and expertise available to Canadians. We have also had a voice in shaping programs and projects that address Canadian and global economic, social and environmental issues.
- Through our international connections, we have been able to promote the products and services of the Canadian geoscience industry abroad.

Some highlights of recent international programs include:

The South American "Borders" Project

GSC has been invited by the Inter-American Development Bank to carry out preparatory work for a proposed four-country geoscience mapping

project in South America. This involves GSC leading a team of Canadian scientists to develop a project preparation document, which will form the basis for a US\$14M project to be conducted by the national geological surveys of Chile, Bolivia, Peru and Argentina in four areas that share common national boundaries. The principal funding body, the Inter-American Development Bank, invited the GSC's participation based on its established record in carrying out similar mapping and resource assessment programs in Canada. Involvement of the GSC at this early stage may lead to opportunities for Canadian geoscience companies should the mapping project go ahead.

Agreement with International Atomic Energy Agency

GSC signed a Memorandum of Understanding with the International Atomic Energy Agency (IAEA), under which GSC will provide technical assistance to the IAEA on a cost-recoverable basis. Since its signing in 1993, ten missions have been mounted for the purpose of assisting other IAEA member nations to assess their uranium resources and identify areas that may have radioactive contamination problems. GSC experts participating in these missions have been able to showcase the equipment and services of Canadian companies, resulting in contracts for Canadian suppliers.

Petroleum Exploration Promotion Project

The GSC provides ongoing support to the Canadian geoscience consulting industry working on international contracts. A good example is a contract in support of the Nepal Department of Mines and Geology executed by the Canadian company, Alconsult International Ltd., aimed at stimulating foreign investment interest in Nepal's petroleum resources. As part of the contract, specialized expertise and facilities unique to GSC's geochemistry laboratory in Calgary were required. Working with Alconsult on a cost-recovery basis, the GSC assisted with field work and provided training, laboratory analyses and data interpretation. The resulting database about Nepalese petroleum resource potential is now being made available to multinational exploration companies (including Canadian companies) to attract them to explore in Nepal.

Canada/Saudi Arabia Joint Economic Commission

The seventh meeting of the Canada/Saudi Arabia Joint Economic Commission was held in Riyadh in January 1994. The Canadian delegation to the Mining and Exploration Committee was led by GSC and included representatives from five

Canadian exploration and mining service companies. The objective was to assist Canadian companies in developing business opportunities in the Kingdom.

International Consortium of Geological Surveys

The application of geoscientific information in today's world is being rapidly redefined. In addition to traditional resource exploration and development end-uses, there are increasing demands for the geoscience information needed to address a diverse range of issues — some economic, others related to social and environmental concerns. As part of its 150th anniversary celebrations in 1992, GSC promoted the formation of a new global partnership called the International Consortium of Geological Surveys (ICOGS). The goal of ICOGS is to create a dynamic interchange amongst national Geological Surveys from around the world. By promoting dialogue and through the sharing of information and expertise amongst geological survey organizations, ICOGS will become a catalyst for innovative and practical strategies to ensure that the geoscience delivered is the geoscience needed by today's complex and rapidly changing world.

INTERNATIONAL COMPILATION PROJECT

GSC's expertise in handling and manipulating large datasets has resulted in 40 organizations from 14 countries becoming involved in a GSC project to compile magnetic observations from the Arctic and North Atlantic oceans, and their adjacent land areas. Participating agencies, which include government bodies, universities and industry, are contributing data with an estimated value of \$.5 billion. GSC will adjust and merge the datasets into one comprehensive digital database that will be of great value for quantitative tectonic interpretations and map production. Plans call for the database to be made available to the geoscientific community in CD-ROM format, while maps portraying the regional magnetic fields of the Arctic and North Atlantic will be available on demand.

The availability of this information will help better our understanding of the resource potential of the continental margins of Canada's Atlantic and Arctic coasts, by providing evidence of past events instrumental in the geological development of the opposite continental margins and intervening seafloor. Globally, it will contribute to our understanding of the nature and origin of the Arctic Ocean, the least known of the world's oceans, and provide the infrastructure for long-term resource assessment of the Arctic margin — one of the world's last reservoirs of significant hydrocarbon deposits.

ARCTIC LOGISTICS

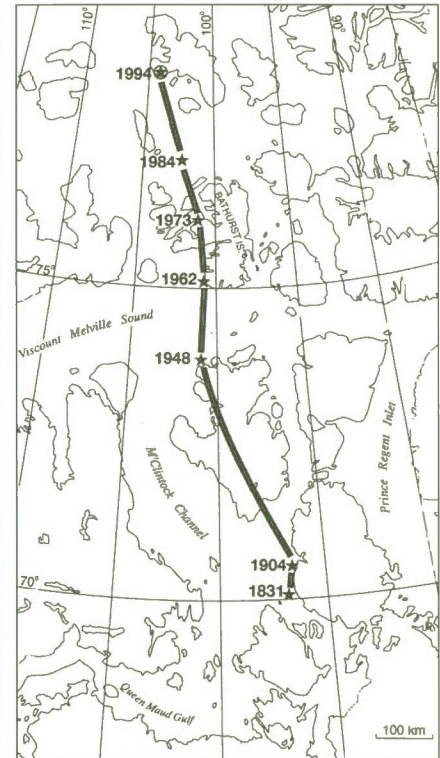
Polar Continental Shelf Project

Polar Continental Shelf Project operates an internationally renowned logistics network for scientists conducting research in the Canadian Arctic. Without the economies of scale possible through a single coordinated service, logistics costs for individual research parties working in the Arctic would be prohibitive.

Since its first season in 1959 when it deployed one field party, Polar Shelf has expanded operations substantially. It now provides accommodation, communications, equipment and fixed- and rotary-wing aircraft support each year to about 240 research groups from federal, provincial and territorial government agencies, Canadian universities and foreign research organizations. Support for Canadian research groups generally is provided on a cost-shared basis, while support for non-Canadian groups is available on a cost-recovery basis.

During the 1993 field season, PCSP worked in partnership with its clients to provide coordinated and cost-effective logistics support to:

- a variety of Government of the Northwest Territories (GNWT), Department of Indian Affairs and Northern Development (DIAND) and GSC geological mapping programs throughout the Northwest Territories to assist and encourage mineral exploration



In early 1994, the GSC carried out a magnetic survey in the High Arctic to redetermine the position of the North Magnetic Pole. This is the point where the Earth's magnetic field is vertical, and a knowledge of the Pole's location is important to the GSC's continuing program of supplying up-to-date information to navigators and cartographers. The Pole was found to be on Ellef Ringnes Island, at 78.3° N, 104.0° W, 150 km northwest of the position where it had been located a decade earlier.

- GSC's NATMAP initiative in the Slave Province to map and describe the geology of the area with emphasis on earth materials, environmental issues and glacial history
- the Canadian Hydrographic Service to identify a safe shipping route through the Coronation Gulf in support of the mining industry and the GNWT
- a GNWT Renewable Resources study of caribou movements to help plan for port development at Coppermine and for the passage of ore carriers along the Coronation Gulf and Dolphin-Union Strait
- a program conducted under the Canada/Russia Northern Scientific Exchange Program to test new geophysical techniques
- a Department of Fisheries and Oceans program to assess the commercial potential of marine groundfish stocks in the offshore waters of Banks Island and to help develop local expertise to conduct offshore winter fisheries

- various university research programs to examine and interpret past climate conditions and to simulate the effects of predicted climate change in future
- Atmospheric Environment Service's air sampling program at Agassiz Ice Cap on Ellesmere Island to monitor air pollution
- experimental oil spill studies to monitor the effects of spills on regional ecosystems over the long term
- a range of archaeological, anthropological and traditional knowledge studies involving community elders and Canadian Museum of Civilization, university, NWT and private researchers contributing to the knowledge of past cultures and environments, and prehistoric hunting and fishing systems.

INFORMATION AVAILABLE ABOUT PCSP PROGRAMS

PCSP distributes an annual newsletter describing research programs seeking logistics support in the upcoming field season. This serves as a useful information tool for PCSP users, Canadian and international science organizations and northern communities.

PCSP's Operations Manual outlines the logistics services provided to science research groups and describes general operating conditions for researchers working in an Arctic setting.

HOW TO APPLY FOR PCSP SUPPORT

PCSP sends out its applications in September each year. The deadline for applications is generally the end of October.

If you wish to be added to PCSP's mailing list, please send your name and address to:

Polar Continental Shelf Project
 344 Wellington, Room 6146
 Ottawa, Ontario Canada K1A 0E4
 Telephone: (613) 990-6990
 Fax: (613) 990-1508

DIRECTORY

How to Get in Touch With Us

Nova Scotia

Atlantic Geoscience Centre
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Challenger Drive, P.O. Box 1006
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B2Y 4A2
Telephone: (902) 426-8513
Fax: (902) 426-4266
Internet: agc.bio.ns.ca

Quebec

Quebec Geoscience Centre
Geological Survey of Canada
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Internet: gsc_bookstore@gsc.emr.ca

Alberta

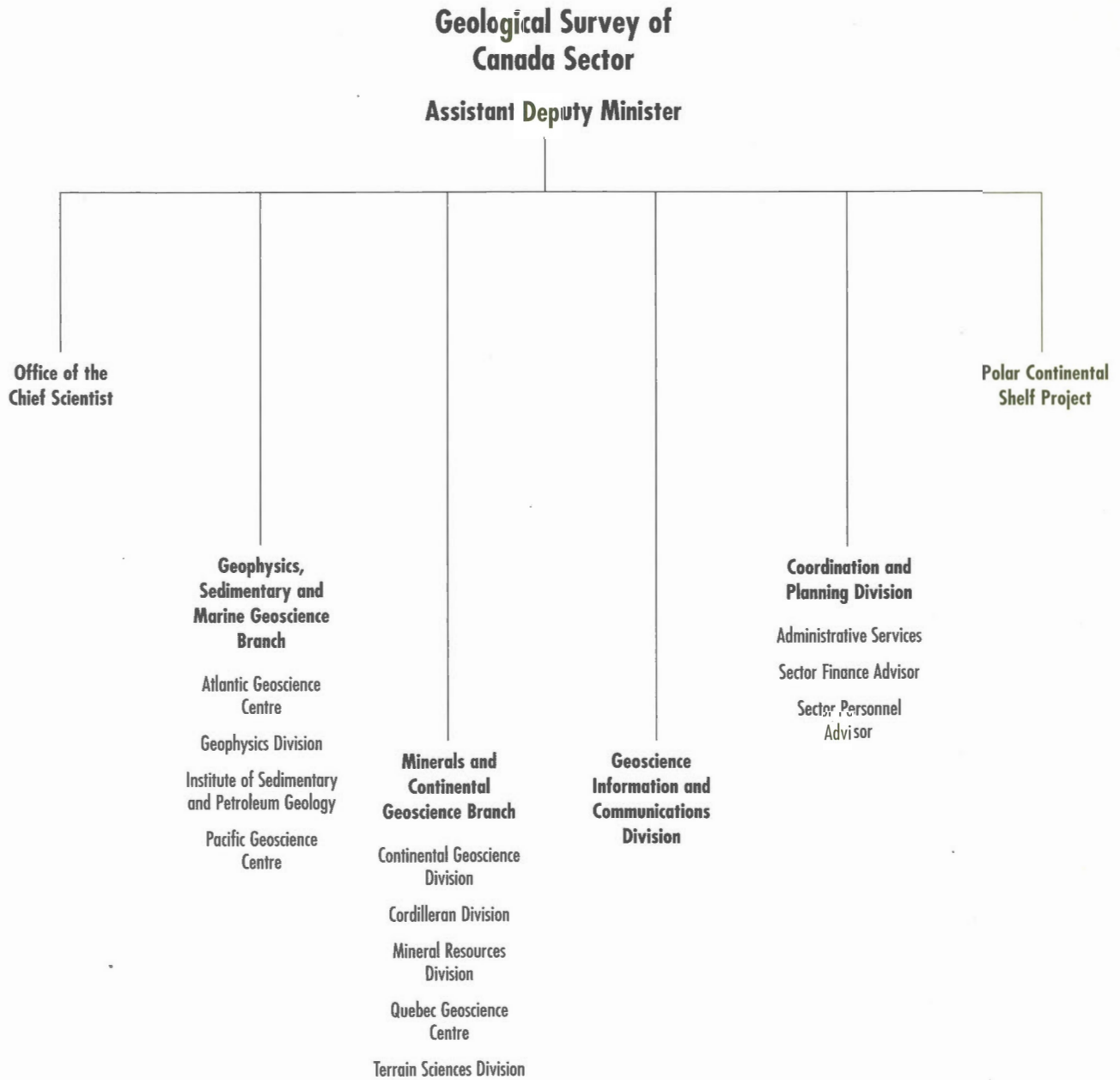
Institute of Sedimentary and
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Geological Survey of Canada
3303-33rd Street N.W.
Calgary, Alberta
T2L 2A7
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Geological Survey of Canada
100 West Pender Street
Vancouver, B.C.
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Geological Survey of Canada
9860 West Saanich Road
Sidney, B.C.
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Telephone: (604) 363-6500
Fax: (604) 363-6739

Organization Chart



FINANCIAL STATEMENT

*Geological Survey of Canada
Financial Statement
1993-94 Expenditures (000's)*



	Total	Salary	Operating	Capital	Grants and Contributions
Assistant Deputy Minister	3,093	251	107	9	2,726
Chief Scientist's Office	174	127	43	4	—
Polar Continental Shelf Project	6,461	1,079	5,010	372	—
Geoscience Information and Communications Division	8,600	4,578	2,583	1,439	—
Coordination and Planning Division	4,061	2,052	1,591	418	—
Geophysics, Sedimentary and Marine Geoscience Branch					
Director General	188	144	44	0	—
Institute of Sedimentary and Petroleum Geology	15,290	8,422	5,589	1,279	—
Atlantic Geoscience Centre	12,981	6,901	4,743	1,337	—
Geophysics Division	10,677	5,862	3,593	1,222	—
Pacific Geoscience Centre	4,866	2,641	1,452	773	—
Total	44,002	23,970	15,421	4,611	—
Minerals and Continental Geoscience Branch					
Director General	928	564	199	165	—
Québec Geoscience Centre	2,911	1,496	1,156	259	—
Cordilleran Division	4,073	2,368	1,479	226	—
Terrain Sciences Division	9,326	5,590	3,124	612	—
Continental Geoscience Division	11,314	5,818	3,005	2,491	—
Mineral Resources Division	14,574	8,432	5,074	1,068	—
Total	43,126	24,268	14,037	4,821	—
Sector Total	109,517	56,325	38,792	11,674	2,726

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