CANADA

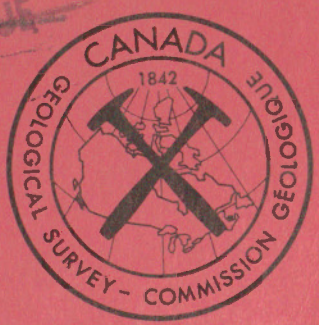
DEPARTMENT OF ENERGY,

MINES AND RESOURCES

GEOLOGICAL SURVEY OF CANADA

ANNUAL REPORT

APRIL 1, 1987 TO MARCH 31, 1988



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OTTAWA

1989

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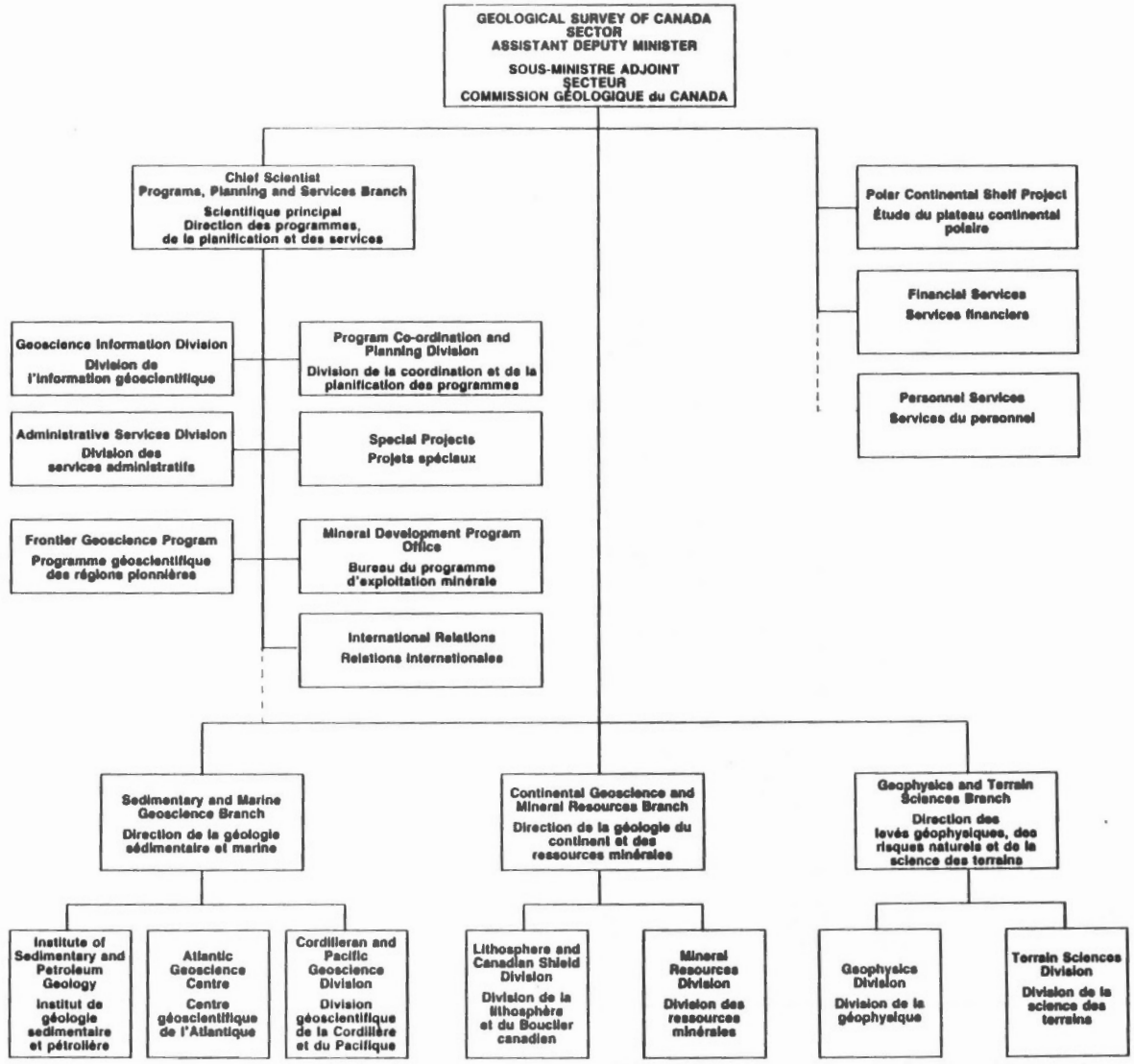
GEOLOGICAL SURVEY OF CANADA
SECTOR
ASSISTANT DEPUTY MINISTER
SOUS-MINISTRE ADJOINT
SECTEUR
COMMISSION GÉOLOGIQUE du CANADA
Chief Scientist
Programs, Planning and Services Branch
Scientifique principal
Direction des programmes,
de la planification et des services
Polar Continental Shelf Project
Étude du plateau continental polaire
Financial Services
Services financiers
Personnel Services
Services du personnel
Geoscience Information Division
Division de
l'information géoscientifique
Program Co-ordination and Planning Division
Division de la coordination et de la planification des programmes
Administrative Services Division
Division des
services administratifs
Special Projects
Projets spéciaux
Frontier Geoscience Program
Programme géoscientifique
des régions pionnières
Mineral Development Program Office
Bureau du programme
d'exploitation minérale
International Relations
Relations internationales
Sedimentary and Marine Geoscience Branch
Direction de la géologie sédimentaire et marine
Continental Geoscience and Mineral Resources Branch
Direction de la géologie du continent et des ressources minérales
Geophysics and Terrain Sciences Branch
Direction des levés géophysiques, des risques naturels et de la science des terrains
Institute of Sedimentary and Petroleum Geology
Institut de géologie sedimentaire et pétrolière
Atlantic Geoscience Centre
Centre géoscientifique de l'Atlantique
Cordilleran and Pacific Geoscience Division
Division géoscientifique de la Cordillère et du Pacifique
Lithosphere and Canadian Shield Division
Division de la lithosphère et du Bouclier canadien
Mineral Resources Division
Division des ressources minérales
Geophysics Division
Division de la géophysique
Terrain Sciences Division
Division de la science des terrains

INTRODUCTION

In April 1987 the Deputy Minister, Energy, Mines and Resources announced major reorganization changes in the Mineral and Earth Sciences Program of the Department. The Earth Sciences Sector was dissolved and the GSC formerly a Branch of that Sector was elevated to Sector level; the Polar Continental Shelf Project was added to the GSC Sector at this time. The new Sector, headed by an Assistant Deputy Minister, was reorganized into four Branches each headed by a Director General.

Dr. W.W. Hutchison, Assistant Deputy Minister, Earth Sciences since July 1981 became Assistant Deputy Minister of the new Sector. Following Dr. Hutchison's death on 3 July Dr. R.A. Price, Director General of the Survey since January 1982 was appointed to the position.

W.W. HUTCHISON

William Watt Hutchison, President of the International Union of Geological Sciences (IUGS) and Assistant Deputy Minister for the Geological Survey of Canada died in the Ottawa General Hospital on Friday 3 July 1987, a victim of cancer. Dr. Hutchison was in his 53rd year.

Born in Scotland in 1935, he graduated BSc from Aberdeen University, and received his doctorate in geology from the University of Toronto in 1962. After a brief period in industry, he joined the GSC and began mapping the Coast Range Plutonic Complex of British Columbia. His flair for developing methods of handling and displaying complex data led to his appointment, in 1974, as Head of the Geological Survey's Data Systems Group in Ottawa.

From 1976 to 1980, Dr. Hutchison was seconded from the Department of Energy, Mines and Resources to the International Union of Geological Sciences (IUGS), one of the largest, most active and influential non-governmental international scientific associations in the world. His term as Secretary General was marked by dynamic enterprise and initiative; he expanded the scope of the IUGS scientific program significantly, improved communications in the Union which includes the membership of just under a hundred countries, and started publishing EPISODES, now well-known as the newsmagazine for international geoscience. These activities brought honour to Canada's role in international science, and in 1980, received the Bancroft Award from the Royal Society of Canada.

He was promoted on 1 January 1981 to the position of Director General of the Geological Survey of Canada. His appointment as Assistant Deputy Minister of the Earth Science Sector followed in July 1981.

At the XXVII International Geological Congress held in Moscow, U.S.S.R. during August, 1984, Dr. Hutchison was elected unanimously as President of IUGS for a five-year term.

At the time of his death, in addition to his responsibilities as Assistant Deputy Minister, he represented Canada on the Circum-Pacific Council for Energy and Mineral Resources, and on the Executive Committee for the International Ocean Drilling Program; he served as a member of the Advisory Board for the Centre for Earth Resources Research at Memorial University in Newfoundland, and on the Scientific Committee for the Institute national de la recherche scientifique (INRS), Université du Québec; he also chaired the Geoscience Program under the Canada/U.S.S.R. Arctic Science Agreement.

CHIEF SCIENTIST'S OFFICE
PROGRAMS, PLANNING AND SERVICES BRANCH

R.P. Riddihough

The Chief Scientist's Office and Programs, Planning and Services Branch were created in April 1987 under the new Geological Survey of Canada Sector. A number of operations and functions with Sector wide responsibilities were inherited from the former Chief Geologist's Office.

The Sector Geophysics Committee, responsible for coordinating national geophysical programs, was continued under the chairmanship of the Chief Scientist. With the retirement of the Chief Geophysicist and the reorganization of the Sector, the Committee was re-established as a committee of Division Directors, reporting to the Sector Executive Committee. An External Visiting Committee on Geophysics, chaired by H.O. Seigel, held its first meeting in December.

The Chief Scientist continued active membership as the Canadian representative on the Tectonics Panel of ODP (TECPAN) and as liaison between the Tectonics Panel and the Central and Eastern Pacific (CEPAC) Panel. Three meetings of TECPAN and two meetings of CEPAC were attended.

The French Language Coordination and Editing Unit, under the supervision of P. Lapointe until December 1987, was largely concerned with the preparation of a Francophone Action Plan for accelerating the improvement of the use of French within the GSC and increasing the proportion of bilingual positions in all categories of the Sector. The Plan was produced and accepted in the Fall of 1987. The Unit, under the supervision of Pascale Coté, and assisted by three translators from the Office of the Secretary of State, worked on DNAG translation.

The transfer of the Communications Office to the PP&S Branch, the departure of C. Vodden on full-time French training and her replacement by A. Pasitschniak took place in September 1987. Previous to that time, under V. Lafferty, coordination with Communications Branch EMR was largely carried out by C. Vodden who also acted as Secretary to the Sector Communications Committee. The Communications Committee was reconstituted under the chairmanship of R.G. Blackadar in early 1988.

Weekly production of the Deputy Minister's Briefing was carried out at various times by A.R. Berger, R.P. Riddihough and transferred to C. Patenaude in the fall of 1987. C. Patenaude also took on the full-time production of Geobriefing.

The Branch provided liaison and advice for the production of technical and promotional videos by Communications EMR, notably Earthquakes in Canada and the Frontier Geoscience Program.

International Relations Office (Including 'EPISODES')
A.R. Berger

This new unit was established in September 1987 under A.R. Berger, replacing the former New Technology and International Programs unit headed by A.G. Darnley.

The Thailand Airborne Survey coordinated by A.G. Darnley, continued to be the largest commitment, and an aeromagnetic survey in Zimbabwe came on stream with GSC providing technical supervision via CIDA.

The Thailand project, financed by the Asian Development Bank, with GSC travel expenses paid by CIDA, commenced in 1984 and is currently scheduled for completion December 31, 1989. The final phase of the airborne operations, a helicopter AEM survey over selected areas totalling 5% of the country, commenced in June 1987. A small number of aeromagnetic maps were delivered during the year. Effective January 1, 1988, W.A. Knappers of Geophysics Division was seconded to CIDA to work on the project full time. G.J. Palacky, Mineral Resources Division, continued to serve as Project Adviser on Electro-Magnetic Methods. During the period February 8-27, 1988, A.G. Darnley attended the annual project review in Bangkok and checked field sites showing abnormal radioactivity.

A report entitled "International Activities of the Geological Survey of Canada: Objectives and Guidelines" was prepared by IRO. After discussion and modification it was approved as formal Sector policy on March 30, 1988.

A new Memorandum of Understanding between GSC and the Geological Survey of Czechoslovakia was signed during the year. There were many contacts with representatives from CIDA, IDRC, EA, Brazil, China, Saudi Arabia, Jordan, Colombia, Gabon, U.K., FRG and the Antarctic on a wide range of issues and activities.

Episodes Secretariat

The Episodes Secretariat, headed by A.R. Berger (Editor), compiled, published and distributed Episodes, the quarterly newsmagazine of the Intrnational Union of Geological Sciences (IUGS), and other IUGS publications, and carried out public relations and promotion work on behalf of the Union. During 1987-88, the Geological Survey of Canada continued to support approximately half the cost of operating the Secretariat, the other half being covered by the Union itself and the revenues generated by sales of Episodes.

Much effort was directed throughout the year to generating high quality contributions to Episodes and promoting sales and distribution. Displays were mounted at several national and international conferences. The Secretariat also continues as the main distribution point for the New Publication Series of IUGS.

Theme I, Canada/USSR Arctic Science Cooperation
(G.W. Cameron)

Coordination for the six main projects under Theme I (Geoscience and Arctic Petroleum) of the Programme of Scientific and Technical Cooperation between Canada and the USSR in the Arctic and the North, was carried out on behalf of the Assistant Deputy Minister, the Theme I co-chairperson.

Highly successful visits by Canadian and Soviet scientists took place to different areas of both countries for discussions and exchange of scientific information, for field work and to plan continued cooperative research. During the year 3 GSC scientists visited the USSR and 7 USSR scientists visited Canada.

Energy Research and Development Program (OERD)
G.W. Cameron

Overall coordination and information distribution for OERD Programs in GSC was provided. The programs are implemented by ISPG, CPM, AGC, TSD, and Geophysics. They are split into 2 major tasks: Task II (6 py, $661K) and Task VI (12 py and $3,279K). Work during the year was centered on providing secretariat for review meetings and ongoing liaison. An independent review committee, to review all of GSC/ISPG coal research, held its inaugural meeting in December 1987. Considerable time and effort was devoted to the revision and negotiation of the text of the Memorandum to Cabinet for the renewal of OERD.

Northern Land Use Planning
G.W. Cameron

GSC representation on discussion meetings with DIAND on a Land Use Plan for Lancaster Sound Planning Region was provided. The Chief Scientist's Office assumed coordination of a multi-agency working group on scientific research. Considerable effort was put into drafting maps and text concerning the role and needs of scientific research in the region. Two meetings were attended in the North and input was provided for compilation and revision of the Plan.

National Geologic Atlas
A.V. Okulitch

Progress on the revision and editing of maps was disappointing this year because of the poor performance of a contractor. However, four maps, correlation charts and supplementary materials are now in press; two were submitted this year. Publication of the first two is expected in late 1988; publication of the second two in 1989.

One map set, expected to be critically reviewed by the end of the report year, has been held back to permit addition of data recently received from a petroleum company. After critical review, it will be submitted for cartography late in 1988. Seven map sets currently await editing; twelve map sets are under compilation.

GSC Paper 87-23 (Atlas standards for a Precambrian time chart) was published. Future plans for the Atlas program were discussed extensively during the year.

EMR Research Agreements and Conference Grants
T.E. Bolton

The GSC received 158 applications to the 1987-88 EMR Research Agreements program with a total request of $1,906,896. We were able to support 90 projects within our budget of $580,000, of which 41 were renewals and 49 were new.

Within the $20,000 grant to assist in defraying the cost of Canadian conferences in the geological sciences, the GSC awarded $16,500 towards publications arising from conferences by 5 organizations, and $3,500 towards four student-oriented geological meetings.

National Type Collection of Invertebrate and Plant Fossils
T.E. Bolton

Between April 1, 1987 and March 31, 1988, 4,084 published type invertebrate and plant fossils were catalogued and added to the national collection and 5,765 numbers were reserved for future publications.

Type specimens in the Ottawa collection were examined by 11 visiting paleontologists and 100 specimens were loaned out for comparative purposes to various paleontologists throughout the world.

At least 20 inquiries for identification of fossil collections by the general public were received either directly or through the National Museum of Natural History.

PROGRAM COORDINATION AND PLANNING DIVISION
J.E. Harrison

The division was established in April 1987 to consolidate a number of functions formerly carried out in the offices of the ADM (Earth Sciences) and of the DG (Geological Survey of Canada). It has five main objectives:

- to provide a framework for program planning, resource allocation, management control and performance assessment in the GSC Sector (which now includes the Polar Continental Shelf Project);
- to maintain information systems (including the Project Management System) required for managerial decision-making;
- to continue liaison with other parts of EMR and with other government departments and central agencies;
- in cooperation with the operating divisions of the Survey, to search for the resources to fund new initiatives;
- to provide a secretariat for the ADM and the Chief Scientist.

During the year, the Division's staff members:

- arranged and took part in a strategic planning conference during which managers and a group of senior and junior scientists examined a variety of policy issues confronting the Sector immediately and in the longer term;
- revised the GSC's Long Term Plan, integrating previous GSC and EPB plans. The Long Term Plan sets the framework for all other GSC planning documents.
- produced a variety of planning and reporting documents to Parliament, central agencies and advisory bodies that demonstrated how the Sector had spent or would spend the ca $100 million of public funds voted annually for its programs;
- analyzed operational and capital expenditure plans of the Survey's divisions and developed reallocation options for the Sector Executive Committee;
- continued the traditional function of monitoring the Project Management System, the basic account of accomplishments of all GSC projects in a given year and of plans for the next;
- developed specifications for a computer based project management system linked to the financial reporting system, and monitored a contract for its development;
- continued to take a major role in directing the three-year refurbishment of PCSP facilities in Resolute and Tuktoyaktuk;
- coordinated the department's Research Agreement Program with Canadian universities;
- contributed to various aspects of human-resource management: annual appraisal and "revitalization" of the Research Scientist group, selection of Visiting Fellows, classification review of the Engineering and Scientific Support group, Official Languages and Affirmative Action plans, etc.
- paid special attention to the projects and program evaluation of the Frontier Geoscience Program;
- developed Memoranda to Cabinet and/or Treasury Board submissions on west-coast earthquakes, the Frontier Geoscience Program, a GSC office in Quebec City and extended funding for the Polar Continental Shelf Project;
- undertook a coordinating role of the Current Activities Forum in Ottawa and encouraged an improved level of poster presentations at this and other geoscience forums.

MINERAL DEVELOPMENT PROGRAM OFFICE

The Mineral Development Program Office is responsibile for co-ordination of GSC activities within the federal-provincial mineral development agreements and within a federal program in Quebec (Le Plan de Développement Economique, Canada/ Gaspésie et Saint-Laurent, Volet Mines). Co-ordinators work with GSC comptroller and divisions implementing the projects on the one hand, and with staff of the provinces and EMR Mineral Policy Sector on the other hand.

FEDERAL-PROVINCIAL MINERAL DEVELOPMENT PROGRAMS

Mineral Development Agreements (MDA), subsidiary to the umbrella Economic Regional Development Agreements (ERDA), have been signed with all provinces except Alberta. MDAs with Yukon and Northwest Territories are subsidiary to the umbrella Economic Development Agreements (EDA).

GSC implemented projects under the MDAs in Newfoundland, Nova Scotia, New Brunswick, Ontario, Manitoba, Saskatchewan and Northwest Territories plus an aeromagnetic project in British Columbia and a regional geochemistry project in Yukon.

Newfoundland MDA - W.H. Poole, Co-ordinator

The fourth year of the 5-year program exhibited full activity levels in 14 projects. Metallogenic studies continued in Labrador in the Central Mineral Belt and in western Labrador. On the Island of Newfoundland, similar studies continued of the western carbonate terrane, the Buchans-Roberts Arm belt, along with groundwater studies at Daniels Harbour Mine. Studies continued on the distribution of sulphides, platinum group elements and gold in the ophiolites of Bay of Islands and Baie Verte Peninsula, Field work was completed in the northern and southern Long Range Mountains. Results of the stream sediment and water geochemical survey in northernmost Labrador were released to the public, and higher density sampling of selected anomalous areas was completed. Results of the gamma ray spectrometer survey flown in the Belleoram-Gander area during 1985 were released and flying for a contract survey, delayed by one year, was completed in the Great Northern Peninsula. Likewise, flying for a contracted aeromagnetic gradiometer survey, delayed for one year, was completed. Studies of the glacial dispersal patterns, central Labrador, were continued.

Outputs consist in part of 22 publications and open files, 17 posters for display, and 7 oral presentations.

Nova Scotia MDA - W.H. Poole, Co-ordinator

Full activity levels marked year 4 of the 5-year program with 18 projects. Seismic surveys in the Cumberland Basin were completed. A final report on the subsea structure of the Port Hood - Inverness coal-bearing beds based on the marine seismic survey, is in review. Input of coal quality data to the National Coal Inventory was completed for the Cumberland coalfield and began in the Pictou coalfield. Metallogenic studies continued in the Meguma terrane, highland areas, and Carboniferous Basins. They included completion of contracted field work in Tangiers, completion of most of the lithogeochemical study of the Goldenville-Halifax transition, near-completion of the data integration project in the Guysborough-Antigonish counties, completion of field work on the Cheticamp area, completion of analysis on the Cobequid catchment basin study, continuation of the studies of anomalous zinc in Antigonish Highlands, completion of a contracted study of Cape Breton Precambrian meta-carbonates and of a contracted study of mineral occurrences associated with the Cobequid-Chedabucto fault zone, completion of a contracted study of rare metals in Sydney coals, and beginning of contracted documentation of the Jubilee zinc deposit. Within the regional geology subprogram, preparation of the final reports on the Stellarton Basin and on northern Cape Breton Highlands continued while the final report on eastern Meguma granites was completed. A contracted sedimentological study of the Goldenville-Halifax transition in Mahone Bay was cancelled, remapping and reinterpretation of the Cobequid pre-Carboniferous rocks continued, a sedimentological study of Horton strata of Cape Breton was started, and remapping and re-interpretation of the Fourchu Group was started. A contracted aeromagnetic gradiometer-VLF survey of the Cobequid Highlands was completed and the much delayed Musquodoboit survey results were finally released. The results of the last of the gamma ray spectrometer surveys, on Cape Breton Highlands, were released. Detailed gamma ray spectrometer surveys in six anomalous areas were placed on open file. A detailed survey over the Davis Lake pluton (East Kemptville tin mine) was flown. Downhole geophysical studies at the Yava mine continued.

Outputs consist in part of 64 publications and open files, 37 posters for display, and 25 oral presentations.

New Brunswick MDA - W.H Poole, Co-ordinator

The New Brunswick program was also fully active with 16 projects. Metallogenic studies continued with a contracted study of hydrothermal zoning in the Woodstock area, a data integration study was initiated, studies of the Mt. Costigan base metal deposit, Elmtree Au deposit and several other studies were continued, the St. Stephen nickel-copper study was completed, mapping and evaluation of the platinum-group elements potential of several mafic-ultramafic bodies was continued, and a contracted study of the potential for uranium

and other elements in central New Brunswick was continued. In regional geology, contracted mapping in the eastern Caledonian Mountains and structural mapping and re-interpretation of the Bathurst camp continued, detailed mapping of the granitoids in northern New Brunswick was completed, and zircon and Pb isotope studies demonstrated the diverse ages of subsurface Precambrian basement to the Miramichi zone. Continued were a contracted study of diagenesis of the Albert Formation, a contracted geochemical provenance study of the Tetagouche Group sediments, and volcanological mapping of the lower Devonian volcanics in Passamaquoddy Bay.

Sampling for a geochemical stream sediment and water survey was completed in southern New Brunswick. Aeromagnetic gradiometer maps for the 1985 survey and the 1986 survey were released, and flying in the southern New Brunswick was completed. Gamma ray spectrometer survey results in the Campbellton- Bathurst area were released, as well as the detailed survey over the 1982 Miramichi earthquake epicentre. Follow-up ground studies of spectrometer anomalies continued and a detailed airborne survey over the Mt. Pleasant caldera (W, Mo, Sn, etc) was started. Surficial geology mapping, till geochemistry and study of ice flow history in northern New Brunswick continued.

Outputs consist in part of 31 publications and open files, 20 posters for display, and 11 oral presentations.

Prince Edward Island MDA

The 3-year program on onshore aggregate resources continued in its second year using $77,000 diverted from GSC A-base.

Ontario MDA - S.B. Green, Co-ordinator

Projects were underway in seven regions of the province during the third year of the 5-year agreement. In eastern Ontario, the study of two high grade sillimanite deposits was completed with submission of a detailed assessment including chemical analysis, petrology and mineral beneficiation. The completed siliceous dolomite project covered over 30 zinc-bearing sites. Mapping and geochemical sampling continued at the Methuen ilmenite deposit and Twin Lakes intrusion. Ten gold deposits were examined and sampled during the first year of a study of gold in the Madoc area. Integration of remotely sensed data collected in the Mazinaw Lake area began. Surficial mapping and till sampling continued in the Westport, Clyde Forks and Perth areas. In the Mid Ontario area, detailed mapping of the Precambrian geology along the shore of Georgian Bay outlined four distinct gneiss associations. In the Ignace area, mapping and drill core examination continued at the Mattabi Mine to further outline the caldera and zones of sulphide mineralization. In the Sudbury-Cobalt area, field mapping and sampling continued in the study of platinum-group element associations in the Nipissing diabase. In the Beardmore-Geraldton area, trenching, sonic drilling and sampling of till was carried out and flying of an aeromagnetic gradiometer survey along 16000 line-kilometres was completed. In the Kenora-Ft Frances area, structural mapping and collection of geochronology samples in areas of gold mineralization continued, sampling and mapping of till in the Lake of the Woods area continued, and flying of an aeromagnetic gradiometer survey along 21000 line-kilometres was completed. At Timmins, underground and surface mapping continued at the McIntyre-Hollinger deposit, and additional samples of scheelite in gold veins were collected in the Timmins-Chapleau area for age determination tests. Sonic drilling of overburden guided by airborne and ground EM surveys has yielded up to four till units in the Timmins-Chapleau area , including the inter-till fossiliferous Owl Creek beds, and has demonstrated that such EM surveys can be used to map the thickness and type of Quaternary sediments and the topography of the buried bedrock surface. Significant differences were found to exist in the gneissic assemblages of the Chapleau and Groundhog River blocks as Precambrian field mapping and sampling continued in those areas. Lake sediment and water samples were collected over a 41000 sq. km. and a pilot study was initiated to sample areas of known platinum-group element mineralization.

Outputs consist in part of 12 publications and open files, 12 posters for display, and 10 oral presentations.

Manitoba MDA - A.G. Galley, Co-ordinator

Nineteen projects were carried out during 1987-88, the fourth year of a five-year mineral development agreement. Projects carried out by the Lithosphere and Canadian Shield Division included alteration, structural and geochronological studies in the Logan Lake and Flin Flon-Snow Lake regions, and geochronological and structural studies in the Thompson region. Field work on the sub-Phanerozoic drilling project was completed and will lead to more accurate interpretation of the underlying Precambrian rocks.

The Mineral Resources Division completed field studies on the gold metallogeny projects in the Flin Flon-Snow Lake and Bissett regions, while PGE and chromite studies were continued in the northeastern and southeastern Superior regions. Continued were detailed studies in the Leaf Rapids and Lynn Lake regions, and a remote-sensing program in the Lynn Lake region centred on the McLellan gold mine. An airborne electromagnetic survey under contract to the Geophysics Division was flown in the Lynn Lake region. The Terrain Sciences Division carried out detailed till studies in several regions between Lynn Lake and Nelson House, and completed surficial mapping between Leaf Rapids and Snow Lake, and in The Pas region.

Outputs include 5 GSC publications, 6 GSC open files, 12 external publications, 17 Manitoba Energy and Mines articles, 2 theses and 20 presentations and displays.

Saskatchewan MDA - A.G. Galley, Co-ordinator

Five projects were carried out during 1987-88, the fourth year of a five-year mineral development agreement. The Lithosphere and Canadian Shield Division completed field work on a project to correlate the stratigraphy of the Kisseynew Sedimentary Gneiss Belt with that of the Flin Flon Volcanic Belt. The Mineral Resources Division completed field studies on gold metallogeny in the Star Lake and Waddy Lake areas of the LaRonge Belt and the Phantom Lake area of the Flin Flon Belt, and continued studies on the PGE potential of mafic-ultramafic intrusions in the Western Craton, Mudjatik and LaRonge Domains.

Results of regional lake sediment and water surveys for the southern Madjatik Domain were placed on open file and reanalysis of samples from previous surveys was continued. The Geophysics Division published preliminary gradiometer survey results for the Kesseynew, Flin Flon Belt and sub-Phanerozoic regions bordering Manitoba.

Outputs include 2 GSC open files, 5 Saskatchewan Energy and Mines articles, 2 outside publications and 5 presentations and posters.

British Columbia MDA

Results of a contracted aeromagnetic total field survey of Vancouver Island and adjacent Strait of Georgia, partly supported by A-base funds, was released and flying of a new area in central British Columbia was completed. In co-operation with B.C. MEMPR, stream sediment and water geochemical maps were produced and released for Whitesail Lake (93E) and Smithers (93L) areas, while maps for Iskut River (104B), 104C and Sumdum (104F) are being prepared using MDA funds.

Yukon MDA

Results of the stream sediment and water survey in Kluane Lake, Snag and Stewart River areas were released. Samples were collected, prepared and analyzed for four areas (105G,H,M(N/2); 115P). Studies continued on the epithermal gold deposits of the Skukum and Mount Freegold deposits. Outputs included 5 publications and open files.

Northwest Territories MDA

The Canada-Northwest Territories Mineral Development Subsidiary Agreement 1987-1991 was signed July 17, 1987. GSC will implement half the geoscience program and will spend $2.85 million over the four years of the agreement. Detailed mapping in the Contwoyto gold belt, in the Baker Lake area and along the eastern margin of the Muskox was started. Mineral deposit studies focussing mainly on gold and platinum group elements began in many localities. Deposits were studied and heavy mineral concentrates, collected along the South Nahanni corridor, were prepared and examined. Deposits of rare metals of uranium were studied.

Outputs included 7 publications and open files, 6 posters for display, and 8 oral presentations.

FEDERAL PROGRAMS, QUEBEC

Asbestos Initiatives, Geoscience Program

The program ended March 31, 1987. Released to the public during 1987-88 were maps derived from the aeromagnetic gradiometer and EM survey over Monts Stoke area. Outputs include 3 publications and open files, 4 posters for display and one oral presentation.

Plan de Développement Economique, Canada/Gaspésie et Bas Saint-Laurent, Volet Mines - Y.T. Maurice, co-ordinateur

Dix projets ont été actifs dans le cadre du Plan de développement économique, Canada/Gaspésie et Bas Saint-Laurent, au cours de l'exercice financier 1987-88. La plupart des travaux ont été exécutés à contrat par des chercheurs universitaires ou des firmes spécialisées.

Dans le domaine de la métallogénie, l'étude tectono-stratigraphique du gisement de Saint-Fabien a réussi à identifier les principaux paramètres qui contrôlent la minéralisation, et à confirmer son age post-Taconique. L'étude de la zone-E de Mines Gaspé, qui en était à sa dernière année, a révélé l'existence de plusieurs zones d'altération superposées qui seraient reliées à différentes phases intrusives. A l'échelle plus régionale, l'étude du zonage hydrothermal autour du gisement de Mines Gaspé a établi les dimensions véritables de la zone affectée par l'activité minéralisatrice. Les résultats de ces travaux permettront de formuler un modèle métallogénique applicable à d'autres systèmes hydrothermaux en Gaspésie.

La compilation de la carte Quaternaire de la Gaspésie au 1:250 000 s'est poursuivie en 1987-88, et cette année on y a ajouté le secteur du Bas Saint-Laurent. On prévoit présenter une version préliminaire de la carte au congrès de l'AQQUA qui se tiendra à Rimouski en septembre 1988.

Un levé géochimique régional des minéraux lourds sur 8000 km^2 de la région du Bas Saint-Laurent a révélé l'existence de fortes anomalies en barium dans le secteur de Rimouski, et en tungstène et métaux usuels (Cu,Pb) dans la région de Esprit-Saint/Trinité-des-Monts. Quelques anomalies d'or ont également été détectées. Ces résultats sont en voie d'être compilés et seront publiés en 1988-89.

La région de Port-Daniel a fait l'objet d'un levé gradiométrique/ électromagnétique héliporté par la firme Les Relevés Géophysiques Inc. de Sainte-Foy. Un levé semblable à l'est de Murdochville a dû être abandonné par la compagnie à cause de conditions météorologiques adverses et persistentes lors des travaux sur le terrain en décembre et janvier. La firme Géophysique Sigma Inc. de Montréal s'est vue attribuer un contrat pour interpréter les cartes gradiométriques du centre-nord de la péninsule produites en 1986 et en 1987.

Le bilan de la production pour l'année 1987-88 s'établit à trente deux cartes aéromagnétiques et six rapports publiés.

OTHER PROJECTS

Deep Seismic Reflection Profile, Quebec and Maine - W.H. Poole, Co-ordinator

Efforts continued to prepare the final reports on the northern end of the profile coupled with the older MERQ line northward to St. Lawrence River. At the same time, in a separate but linked project, all data along the entire profile from the St. Lawrence to the continental edge off the Gulf of Maine is being digitized for interative and comparative study.

Personnel Notes

At year-end, the Office consisted of W.H. Poole, in charge of the Office and of the Newfoundland, Nova Scotia and New Brunswick mineral development agreements; Y.T. Maurice for Plan de Développement Economique, Canada/Gaspésie et Bas St-Laurent, Volet Mines; A.G. Galley for the Manitoba and Saskatchewan mineral development agreements; part time administrative officer, J.G. Arnold; and a full time clerk, S.J. Kelly. Dr. Maurice and Mr. Galley also carried out scientific studies.

ADMINISTRATIVE SERVICES DIVISION
Y. Claude

The Administrative Services Division of the Geological Survey of Canada Sector is comprised of four units, namely the Procurement, Chemicals and Stationery Stores; Building Maintenance, Inventory and Vehicle Services; Branch Records and Messenger Services; and the Word Processing Centre. The responsibility of these sections is to provide administrative support and services to the Ottawa based Divisions as well as functional guidance and advice to the Regional Offices.

Administrative Services also provides administrative guidance and advice to the Geological Survey Sector on all administrative matters by assessing the implications of new and changing Treasury Board policies and guidelines and departmental directives upon the administrative support staff and the operational divisions and implementing them as they relate to the Sector. The Division also administers the accommodation plans; the Security/Safety Programs and the Emergency Disaster program; coordinates field logistic requirements; and controls the Branch Parking allocations.

Major Accomplishments/Changes

- new Word Processing Centre equipment connected to file servers and laser printers for the preparation of GSC publications.
- the creation of a Safety/Security Officer position, to initiate a management awareness program and the revisiting of all safety policies and procedures.
- the conversion of the Geophysics Inventory to the NATO Classification System and the tagging of 4,688 individual items of which approximately 1,000 requires the preparation of data sheets for the creation of a DND NATO number.

Personnel Notes

Staff changes include: Arrivals - Violet Rombough to the Records and Messenger Services Unit; Andy Zicat to the Building, Vehicle Unit; Daniel Gariépy to the Inventory Management; Jean-Guy Beaulne to the Shipping and Receiving Unit; Doug Janney to the Safety and Security Office; Danielle Bonney to the Director's Office; Departures - Francine Mellor from the Word Processing Centre; Daniel Gariépy from the Inventory Management; Kathy Gareau from the Director's Office.

BRANCH FINANCIAL SERVICES

The Branch Financial Services in the Geological Survey consists of Budgeting and Planning and, Accounting Operations both of which are the responsibility of the Director.

Budgeting and Planning's main responsibilities are:

i) The coordination of the annual Multi-Year Operational Plan and Main Estimates.

ii) The coordination and control of the Branches' monthly expenditure forecasts and variance analysis.

iii) Implementation of Treasury Board guidelines and departmental procedures relating to financial planning.

iv) Providing advice to divisional administration officers on matters pertaining to finance.

Accounting Operations main responsibilities are:

i) Processing and auditing of all supplier accounts, field accounts, travel and removal claims and other miscellaneous accounts, for all Branches of the GSC.

ii) Payment and processing of all invoices for the DG-PPS and Sector Administration.

iii) Payment of centralized billings such as freight, Central Travel Service, telephone and taxis.

iv) Implementation and regulation of all Treasury Board guidelines relating to accounting operations.

v) Provide advice to divisions on accounting systems and procedures.

The following staff changes took place in Financial Services during the 1987/88 fiscal year:

Bowie, David:
Joined Financial Services as the Head, Accounting Operations as part of the FI Generic, job rotation program.

Clisch, David:
Joined Accounting Operations on a term basis since June, 1987. Dave last worked with National Research Council.

Hall, Diane:
Left Accounting Operations to join CANMET on a permanent basis.

Smith, Judy:
Seconded to Accounting Operations as of January, 1988 from Legal Surveys Division of Surveys and Mapping Sector.

Stapledon, Jeffrey:
Seconded to Program Coordination and Planning Division in November for a period of one year as acting Chief, Management Information.

GEOSCIENCE INFORMATION DIVISION

R.G. Blackadar

During 1987-88, the division comprised five reporting units: Scientific Editing and Publication Production, Library Services, Cartographic and Reproduction Services, Data Systems, and Administration Services. In January 1988 the Special Projects Translation Co-ordination and Editing Unit was transferred to the division and was incorporated as a unit of the Scientific Editing Section. This unit was established in January 1987 under the ADM's office to facilitate the translations for major GSC reports such as resource evaluation studies and the 9-volume "Geology of Canada" series.

During the report period about 5800 pages of new scientific text (including more than 500 pages in French) were processed as well as more than 1000 pages of general text such as popular booklets, open files, etc. Included in the scientific output was the 6-volume 1275 page "Current Research" series which was released in less than three months following manuscript submission.

During 1987-88 the following were published:

9	bulletins
3	memoirs
36	papers
6	miscellaneous reports
28	multicoloured maps
31	preliminary maps
822	geophysical maps
154	Open Files

In the Library demands for service continued but of greatest concern was the dramatic increase in the cost of books and journals which resulted in the acquisitions budget being exhausted by mid-year. The cost of periodicals has gone up 70% since 1983; monographs by 32%. The need for a $100K increase in the budget was brought to the attention of the Sector Executive Committee but no final decision was made by year end.

Scientific Editing, Publication Production and Distribution Section

W.C. Morgan

The role of this section is to ensure that the results of the GSC research programs are made available to users in forms that adhere to high standards of quality and yet are cost-effective.

A major commitment for the next few years will be the processing and publication of the 9-volume "Geology of Canada" series in both English and French editions. During the report period, editing of the "Geology of Continental Margin of Eastern Canada" volume (English) was carried out within the division; similar editing was carried out by the Terrain Science division editor for the "Quaternary Geology of Canada and Greenland" volume and translation of this volume was started by the divisions Special Projects Translation unit.

During the year, a massive revision of the mailing list for the Monthly Information Circular was completed. About 2000 names were dropped. Most of these were individuals who did not reply to our questionnaire - incorrect addresses, being the main cause. The list now stands at 4500 with about 50 new names being added monthly.

The use of credit cards was implemented in July 1987 and has proven popular with our customers as well as reducing the time spent by GSC staff in sales accounting.

Distribution Data

Maps	86 182
Reports	33 392
Indices, posters, listings, etc.	136 633
Total	256 207

Other Data

Requests for publications, rock and mineral sets, etc.	16 031
Telephone enquiries	5 645
Correspondence, invoices, etc.	3 742
Visitors to Ottawa Office	
Cash sales	1 038
Others	1 705
	2 743

Revenue

Sales	$156 994.05
Products supplied to Calgary and Vancouver sales offices	$125 941.25

Library Services

A.E. Bourgeois

The GSC Library's role is to provide information services in support of the research mandate of the Geological Survey and to maintain a national resource collection in earth sciences and related disciplines to support Canadian geoscience research. The Library and the National GEOSCAN Centre continue to perform the activities related to the selection, acquisition, analyses and description, processing, retrieval and dissemination of literature which are required to meet demands for high quality and immediate information.

At the request of the Branch Director General background information supporting a request for a major increase in the acquisitions budget was prepared. It was pointed out that the concept of the GSC being responsible for the "national geoscience collection" evolved as a logical adjunct of our Canada-wide research activities. As a result the GSC now houses one of the oldest and rarest collections second in size only to that of the U.S. Geological Survey. If GSC cannot increase

its libraries acquisitions budget it is not likely that other national libraries will fill the gap. The result will be that there will be no national geoscience collection. The report noted that the cost of periodicals had risen 70% since 1983 and that of monographs by 32%. In 1983 the library purchases 652 periodicals and 1104 monographs; in 1987 only 599 periodicals and 592 monographs were purchased. Money that would have been used to buy books was diverted to keep the purchase of periodicals from falling even further behind.

The problems raised were discussed by Sector managements but remained unresolved in May 1988.

INFORMATION SERVICES

Reference and Circulation

In addition to its on-going activities the following projects were undertaken:

1. Weeding of periodicals was continued
2. A major reorganization of the collection was undertaken to accommodate growth
3. Documentation for the PEBILL database was completed

Map Library

1. In addition to on-going cataloguing of current maps, the cataloguing of the map series backlog is continuing. 80% of map series have been put into GEOCAT.
2. The Head of the Map Library gave a presentation on collection development in a specialized collection, as part of a panel on collection rationalization, at the ACML Conference, 1987.

TECHNICAL SERVICES

Acquisitions

1. All ordering is now centralized for GSC collections in the NCR.
2. The acquisition activities continue to be plagued by large increases in publication prices; the number of items purchased has decreased because our budget has not kept up with inflation.
3. This section participated in a pilot study prior to the implementation of the new financial system.

Cataloguing/Descriptive Data

1. The Series Authority and Name Authority files are now fully automated.
2. The Library's database now controls uncatalogued material (gifts); this has greatly enhanced the retrievability of information.
3. Advance training in MINISIS was provided to staff, thus increasing the computer literacy of the Technical Services Unit.
4. Conversion of theses records to machine-readable format was completed by a "FUTURES" trainee.
5. Training of a "back-up" database manager has been completed.

Systems Management

1. Problems with the financial reporting system have been resolved.
2. An Interlibrary Loan system was installed at HQ Library.
3. A major reorganization of the programme and the system for the reproduction of the microfiche catalogues has been initiated. Preliminary testing has taken place and problems have been identified and are being corrected.
4. Plans for the installation of a MINISIS-based cataloguing and acquisition system at ISPG have been completed.
5. A download menu for REFLECTION software has been devised. This will permit direct downloading to disk.

NATIONAL GEOSCAN CENTRE

NGC continued to provide support for all aspects of the management of the GEOSCAN/MINISIS Project, a cooperative federal provincial program. This included batch and online data entry, thesaurus loads and updates, authority file control and general maintenance of system files, ensuring quality control, training indexers and searchers, maintaining system and database documentation, processing information and product requests, promoting GEOSCAN, maintaining communications with participating agencies, coordinating data transfer activities between GEOSCAN and satellite files, administering the facilities management contract with Systemhouse Ltd., and functioning as HP3000 System Manager.

In addition the following major tasks were undertaken:

1. Several new files were mounted: Saskatchewan (4000 records), Manitoba, Theses (Saskatchewan and GSC Library); Agreement in principle has been reached to include in GEOSCAN the publications of the British Columbia Department of Energy, Mines and Petroleum Resources.
2. Discussions are continuing with CISTI to mount GEOSCAN on the CAN/OLE II database marketing system. There will be a 12-18 month delay as CISTI is presently upgrading its systems.
3. The NGC underwent a reorganization to improve control over the indexing of GSC publications by creating an indexer position. A significant backlog of GSC Geophysical maps were eliminated and backlogs in other series were either reduced or eliminated.
4. NGC participated in the development and implementation of the GSCPUBS database by data entry, training indexing staff and providing advice and expertise.
5. NGC staff played an active role in the planning and implementation of a major system upgrade to our HP3000 minicomputer.

STATISTICS : 87/88
GSC LIBRARY AND THE NATIONAL GEOSCAN CENTER

		TOTALS
Information Delivery		
Supplied by Library		17 128
General reference	14 149	
Literature searches	2 979	
CAN/SDI profiles	109	
Supplied by NGC		148
Custom indexes	34	
Online retrievals	94	

Advisory/Orientation	20		
Referred to other sources			412
Document Delivery			
Requests processed			48 521
% for GSC clientele	69	%	
% for External clientele	31	%	
Items supplied			
from GSC collection	94	%	45 706
from other libraries	3	%	1 404
Locations provided	.5%		209
Items not supplied	2.5%		1 202
Document Analysis			
Monographs, serials, etc	6 671		9 382
Maps	426		
GSC publications	2 331		
Collection Growth			
Monograph volumes	1 607		8 880
Map sheets	4 374		
Microforms (reels/sets)	1 041		
Serial volumes	1 858		
Linear meters			250.5
GEOSCAN Participating Agencies			14

DATA SYSTEMS SECTION

P.B. Charlesworth

Section Chief continued to provide advice to sector management and staff on Information Systems policy, planning and technical issues. There was an increased need for policy and planning advice at the executive level as a result of the EMR management review process. Part of the section continued to evolve into a geoscience oriented information centre as more and more of the sector's professional staff acquired microcomputers and required advice and hands-on support. Major accomplishments included the installation of the section VAX 8700 and the completion of pilot projects using automated cartographic techniques in co-operation with the Cartographic Section and using GIS techniques in co-operation with the USGS.

CARTOGRAPHIC AND REPRODUCTION SERVICES

J. Bill

The Section provides a comprehensive cartographic/graphic, photomechanical and photographic service to the GSC Sector. A broad variety of products are produced ranging from simple white prints to the production for offset printing of highly complex multicolour geology maps. This includes colour graphics for displays and slides for talks and presentations; charts and illustrations for published reports; base maps for field work and map manuscript preparation. A general and specialized technical photographic service is also available.

Increases to several work load components continued through this year. An increase of almost 5% in the number of miscellaneous requests processed by the Photomechanical Unit brought this total to nearly 2,000. More significant was the increase to the miscellaneous drafting work load. Although the number of projects handled remained unchanged at 484, the number of person hours required to process them increased by over 30% to 14,115.

The Technical Photography Unit was able to resume full service, with the completion of renovations and the staffing of a vacant photographer's position. A new colour print processor was acquired enabling faster output and higher quality of Cibachrome prints.

Computerization of the Photo Library's catalogue system was started using a microcomputer based system.

The cartographic production for DNAG continued with nearly all work completed by those chapters received for two volumes; Geology of the Continental Margin of Eastern Canada and Quaternary Geology of Canada and Greenland.

Cartography handled the contracting out of a growing number of MDA projects, increasing supervisory time spent on contract administration.

The Geology and Geophysics volume of the Marine Science Atlas of the Beaufort Sea was printed and bound late in the year.

A colour film recording system was installed in Cartography late in the year. The system will be used to produce presentation quality slides from computer generated graphics. Slides can be created, either directly on the system of through imported graphic files from a variety of minicomputer or microcomputer based software packages, with a resolution of up to 4,000 x 2,700 pixels.

A project automating the colour separation for a multicolour geology map was successfully carried out. Colour separations for Map 1682A, Quetico, were produced digitally using an Optronics 4040 scanner/plotter at CLDS, Environment Canada.

This totally eliminated the need for peelcoats and the slow and tedious manual process of peeling them to obtain required map unit colours.

PRODUCTION DATA

Cartography

Maps and illustrations received during the fiscal year:

	1986-87	1987-88
Multicoloured geological maps	32	24
"B" Series Maps	1	9
Figure illustrations (pocket)	10	12
Figure illustrations (page)	585	565
Geophysical Maps and Indexes	14	25
Special Projects:		
-Beaufort Sea Atlas	0	0
-Misc. Maps	14	10
-Panels for Displays	7	3
-MDA Maps - Misc.	57	0
-Mad Maps - "A" Series	0	6
Open File Maps	377	179

Maps and illustrations completed by the Cartography Section:

	1986-87	1987-88
Multicoloured geological maps	15	21
"B" Series Maps	8	7
Figure illustrations (pocket)	22	9
Figure illustrations (page)	152	308
Geophysical Maps and reprinted	16	48
Indexes to Publications revised	40	0
Open Files Maps and Profiles	105	134
Special Projects:		
-Panels for Displays	7	3
-Beaufort Sea Atlas	0	46
-Misc. Maps	11	15
-MDA Maps - Misc.	57	0
-MDA Maps - "A" Series	0	0

Carry-over of maps and illustrations in progress at the end of the fiscal year:

	1986-87	1987-88
Multicoloured geological maps	46	49
"B" Series Maps	4	6
Figure illustrations (pocket)	13	16
Figure illustrations (page)	501	827
Open File Maps and Profiles	272	45
Geophysical Maps and Indexes	31	25
Special Projects:		
-Beaufort Sea Atlas	77	31
-Misc. Maps	3	0
- MDA Maps - "A" Series	0	6

There were 484 miscellaneous (Z numbered) drafting jobs completed during the year, which took 14,115 person hours.

A total of 585 requisitions for digital typesetting services for Ottawa Cartographers were keyed and coded in-house for processing at S & M Branch. This is an increase of more than 10% over previous year.

Photomechanical:

Camera	1986-87	1987-88
Film and paper line copies	7,290	2,854
Direct B & W prints (PMT)	1,999	2,160
Direct colour prints (PMT)	147	132
Halftones	168	298
Continuous tones	30	91
Contact		
Film and papers	29,208	33,455
Keys	938	645
Peelcoats	474	541
Transfers	14	-
Final Pre-Screen	484	1,291
Colour Proofs	313	1,693
White Prints	8,500	9,113

In addition to the normal map production operations, the photomechanical unit processed 1,991 (X numbered) miscellaneous jobs for various authors and Divisions.

There were 643 master topographic negative packs requisitioned from S & M Branch for reproduction in Photomechanical for authors and cartographers in Calgary, Ottawa and Vancouver.

Automation Unit:

Digitizing:	1986-87	1987-88
MRD	93	50
TS	8	-
LCSD	6	-
GEO	3	25
	110	75

Digitizing training sessions on AutoCad - 9 weeks
Installation and testing Zenographic Software (Film Recording System) - 3 weeks

Twenty-one projections at various scales were prepared with the cooperative assistance of the S & M automation system.

Checking Unit:	1986-87	1987-88
'A' Series maps checked at proof stage	19	19
'B' Series maps checked at proof stage	3	2
Pocket, page figures, misc.	37	5
Atlas pages	39	-
	98	26

Photography:		
Photographs Produced:	1986-87	1987-88
Equipment-Labs-Portraits-etc.	144	186
Continuous tone maps-charts	1,888	622
Line copies	215	188
Rock & mineral specimens	536	508
Thin sections	381	260
Fossil negatives	249	187
Colour slides	4,998	5,145
B & W slides	624	527
Duplicate slides	1,443	1,512
B & W negs. from colour slides	1,101	555
Overhead Transparencies	-	61

	1986-87	1987-88
Prints and Enlargements:		
B & W	8,225	7,176
Colour	723	1,742
Prints from Photo Centre	2,459	2,512
Other Operations:		
Prints and Enl. number and stamped	1,712	270
Prints and Enl. to outside agencies	557	313
Slides mounted	6,844	7,648
Requisition processing - rolls	104	106

Personnel Notes

Bob Daugherty retired as supervisor in Unit B after 37 years of service with the G.S.C.

Three cartographers joined us to assist with DNAG work load. Catherine Mayer and Ted Callahan in term positions, and Tim West on secondment from LCSD. Catherine Mayer left later in the year for a position in Toronto and was replaced by Graham Carmichael.

Don Ransom occupied a term position in B Unit while Sylvia Frohberg was on maternity leave.

Victor Dohar joined the staff of B Unit last fall in an indeterminate cartographer position.

Jeffery Dubois was the successful candidate for the vacant photographer position, coming to us from Kenting Earth Sciences.

CONTINENTAL GEOSCIENCE AND MINERAL RESOURCES BRANCH

D.C. Findlay

LITHOSPHERE AND CANADIAN SHIELD DIVISION

J.C. McGlynn, Director

INTRODUCTION

The Division is responsible for all aspects of the bedrock geological framework of the Canadian Shield as well as serving as a national centre for studies of the Canadian lithosphere.

The objectives of the Division are: To ensure the availability of comprehensive knowledge, technology and expertise concerning the deep geology and geophysics of the Canadian lithosphere; concerning the bedrock geology of the Canadian Shield, particularly with reference to mineral deposits; and concerning geochronology and paleomagnetism in Canada. Specifically, the division is responsible for the bedrock geology, tectonics, gravity, magnetics and seismic studies within the Canadian Shield and within the Appalachians in New Brunswick, Nova Scotia and Newfoundland.

The division serves as a national centre for studies in non-Quarternary geochronology, petrology, paleomagnetism and of the Canadian lithosphere, using a multi-disciplinary approach with emphasis on the integration of geological and geophysical (seismic, electromagnetic, gravity and aeromagnetic) data.

The Division is organized into eight sections and a special projects group. Three of the sections are responsible for the regional geology of the Canadian Shield and are named after the structural provinces in which they work; Bear-Slave, Northern Churchill and Superior-Grenville. These sections report their bedrock studies on geological maps at various scales and in reports and scientific papers. The Geochronology, Petrology and Paleomagnetism sections provide isotopic, petrologic and paleomagnetic studies by which age relations and processes of formation of rock assemblages are established. The Seismology and Electromagnetism and Potential Fields sections provide seismic, electromagnetic, gravity and aeromagnetic studies to define the deep crustal structure of the Canadian lithosphere. Special studies in the Division undertake bedrock studies in volcanology, Precambrian tectonics and Lower Paleozoic geology of Eastern Canada.

The mix of disciplines in the Division makes possible multidisciplinary studies and increasingly groups of scientists with a variety of expertise will focus on important national problems or on critical regional tectonic zones as well as on deep crustal studies. Priorities include application and testing of plate tectonic theory to Precambrian and deep crustal studies.

The establishment consists of 100 person-years for A-base indeterminate scientific and administrative staff, term research assistants and students for summer field work and 7.50 person-years for research scientists, assistants and students employed on the federal-provincial Mineral Development Agreements, the Asbestos Initiatives Program and the Frontier Geoscience Program.

BEAR-SLAVE SECTION

M.B. Lambert (Head)

Highlights

In recent years field work with Bear-Slave Provinces in the northwestern Canadian Shield has focused on the major tectonic zones namely the Wopmay Orogen in the Bear Province and the Thelon Tectonic Zone along the eastern border of the Slave Province. This year the emphasis was on the southern extension of the Thelon Tectonic Zone and on the central Slave Province. In the latter area, new thrust was initiated to develop a modern synthesis of Archean tectonics, to produce a series of modern 1:250, 000 geological maps as well as a few strategically located 1:50,000 maps that are so much in demand by the exploration industry.

Structural investigations along the southern boundary of the Slave Province demonstrate that the Great Slave Lake Shear Zone (GSLSZ) extends to the northeast of Snowdrift River and joins the southern extension of Thelon Tectonic Zone. South of Great Slave Lake Shear Zone major early Proterozoic strike-slip shearing occurs in two regions: northeasterly trending shear near the GSLSZ and northerly trending shear along the east margin of Taltson Magmatic Zone through Lady Grey Lake. Each region contains both sinistral and dextral shear. In the former, northwest sinistral and dextral shear may have formed conjugate fault zones but in the latter sinistral shear preceded dextral shear. These major shears probably developed in harmony with different phases of tectonic activity related to Great Slave Lake Shear Zone.

Zircon and monazite U/Pb geochronology on plutons within Taltson Magmatic Zone suggest the following preliminary conclusions: (1) the core of the Konth Batholith is 5 to 10 Ma younger than peripheral lobes suggesting a central diapir; (2) sinistral shearing and mylonitization is in part younger than 1935 Ma.; and (3) an estimate for the maximum age of dextral shearing in the Taltson Magmatic Zone is 1906 Ma., coeval with the youngest plutonism in the Thelon Tectonic Zone.

A new project in the Contwoyto Lake area of the central Slave Province initiated regional mapping and tectonic interpretation, and detailed structural analysis of supracrustal units. Archean deformational history of the area includes at least three phases of folding, two phases of cleavage formation and shear zone development. Proterozoic deformation includes large-scale folding and oblique dip-slip faults. The final structural geometry defined by three superposed deformations has been partially modelled, providing a potential tool for exploration in the area. Isotherms and isobars of low P- High T Archean metamorphism define undulating, possibly folded surfaces. Six phases of Archean intrusion range in composition from gabbro to syenogranite. The state of strain, 3-dimensional form and inferred mechanism of intrusion of plutons has led to the hypothesis that emplacement had relatively little effect on deformation of the country rocks, although diapiric emplacement of the fifth phase resulted in significant rotation of country rocks. Preliminary geochemical data are compatible with igneous activity in an arc-type environment.

Near the northwestern part of Bathurst Inlet, a paleokarst horizon (documented for 65 km) developed in middle Proterozoic Parry Bay Formation within the sedimentary and volcanic sequence of the Elu Basin, which unconformably overlies the Goulburn Supergroup. Bitumen discovered in the Parry Bay dolomites on Kent Peninsula represents gilsonite that was subjected to pressurized thermal shock inferred to be associated with high temperature fluids related to extrusion of the Ekalulia flood basalts.

In the Tinney Hills area, along the eastern coastline of Bathurst Inlet, stratigraphic facies in the lower part of the Bear Creek Group of the Goulburn Supergroup record a transition from shallow shelf environments fringing the outer trench slope of foredeep (Slave Craton) to deeper slope and basinal environments of the foredeep trench axis. The Burnside Formation of the Bear Creek Group represents a westward-prograding braid-delta/braid-plain system which blanketed the northwestern Slave Province and interfingered with the passive margin of the Epworth Group of Wopmay Orogen. Stratigraphy suggests deposition in an asymmetrically-subsiding foreland basin that drained the Thelon Tectonic Zone and its hinterland.

In The Wopmay Fault Zone of the Bear Province north-trending folds of Dumas Group and its basement are continuous over the entire length of the Calder River map area. Rocks of the Grant Group unconformably overlie gneisses of Archean age. In the Hepburn metamorphic-plutonic zone, a window through Archean gneisses exposes metasedimentary rocks of the Akaitcho Group and their gneissic basement, both of which have been overthrust by the upper slab of Archean gneisses. In the Great Bear magmatic zone supracrustal rocks of the Ellington Lake area are probably correlative with rocks of the LaBine Group to the west and of the Dumas Group to the east.

Initial systematic sampling and examination of the marginal zones of the Muskox Complex in the northern District of Mackenzie has led to a working hypothesis for the genesis of the marginal gabbro norite and its relationship to the bulk of the complex. Residual magma from the crystallizing interior of the intrusion may have risen along the walls, altering the original feldspathic peridotite to the present gabbro norite. Trace element distributions, currently being analysed, may be helpful in testing the hypothesis.

NORTHERN CHURCHILL SECTION

A.N. LeCheminant (Head)

Highlights

Northwest parts of the Churchill Province and most of Baffin Island have a complex tectonic history which locally extends back more than three billion years. Unravelling the long history requires detailed isotopic, petrologic and kinematic studies coupled with a strong mapping program. During the 1987 field season 1:250,000 mapping continued in northern Boothia Peninsula and was completed in the Chesterfield Inlet area. Detailed structural mapping along the southern margin of the Piling Group in central Baffin Island was initiated. 1:50,000 mapping, combined with geochronology and metallogenic studies, continued in the Schultz Lake area west of Baker Lake.

Mapping within the Precambrian core of northern Boothia Peninsula identified a medium-pressure granulite terrane made up of orthopyroxene-bearing quartzofeldspathic gneiss and two belts of metasedimentary rocks. Gneissic trends, reflecting major third-phase folding, are steep and dominantly NNE-NE, except in the western and northernmost part of the region where northerly trends are continuous with trends on Somerset Island. U-Pb zircon and monazite geochronology has been obtained for highland regions of southeastern Ellesmere Island and eastern Devon Island. The results indicate Archean crust (2.52 Ga) underlies Devon Island. On Ellesmere Island granitic intrusion at 1.96 Ga was closely followed by granulite-grade metamorphism and deformation with additional (uplift-related?) melting prior to 1.91 Ga.

The most complete sections of the Archean Prince Albert Group are exposed on Melville Peninsula. Near Richards Bay a 5 km thick inverted section contains both subaerial and subaqueous volcanic units with intercalated continental sedimentary rocks. The tectonic setting is interpreted as ensialic and tensional with deposition on pre 2.9 Ga basement. Felsic to intermediate volcanic rocks are overlain by more primitive basaltic and komatiitic flows. This change may be due to drawdown of a crustally contaminated ultramafic magma chamber, variable contamination of ultramafic magmas during ascent, or progressive changes in the degree of partial melting in the mantle source region.

U-Pb geochronology places new constraints on the Archean magmatic and metamorphic history of central and northern Baffin Island. Zircon ages of 2709, 2718, 2734 and 2767 Ma for monzogranite, acid and mafic metavolcanics and granitic migmatite define a major late Archean magmatic event in north central Baffin Island. An earlier igneous event is indicated by a foliated tonalite with an age of 2853 Ma. Considered with previously published Nd-Sm, Rb-Sr and oxygen isotopic data the geochronology indicates most of the crust that underlies Cumberland Peninsula and northwest Baffin Island separated from the mantle about 2.7 to 2.9 Ga ago, although indications of older crust occur locally. Geochemical classification of Archean metavolcanic rocks and crosscutting granites suggests affinity with magmatic suites emplaced in modern volcanic arc and collisional settings. Late Aphebian granites (1.8-1.99 Ga) emplaced in south-central Baffin Island were derived chiefly by remobilization of Archean crust. Magmatism accompanied or was closely followed by regional deformation and high-grade metamorphism.

Mapping in the Dewar Lakes region of Baffin Island concentrated on details of metamorphism, structure and stratigraphy along the southern margin of the Aphebian Piling Group. Mafic-ultramafic rocks in the Piling Group are differentiated flows and sills ranging in composition from pyroxenite to diorite. The flows are conformable with fine-grained, graphitic and sulphidic, quartz-rich schist. Basal quartzite and metapelitic gneiss contain coarse sillimanite, staurolite and garnet, whereas, the immediately overlying metagreywacke sequence is at biotite-muscovite grade. This suggests a very steep or telescoped metamorphic gradient. Structural studies reveal an initial bedding-parallel tectonic fabric (S1) in the supracrustal rocks that possibly developed during regional horizontal extension. This fabric is overprinted by at least three episodes of nearly coaxial upright and recumbent folds which resulted in a fold interference pattern dominated by many low amplitude Archean-basement-cored periclinal

anticlines. The anticlines are elliptical in plan with E-W trending mineral stretching lineations. The basement cored anticlines are aligned on the crest of a N-S trending basement high.

Mapping within high grade metamorphic complexes north of Chesterfield Inlet has revealed an ENE to NE trending folded remnant of a late Archean or Early Proterozoic ductile thrust. The high-strain zone appears to link to the northeast with the outer shear zone of the Daly Bay Complex, one of a number of high-strain zones associated with the uplift of granulite-anorthosite complexes exposed between Baker Lake and Daly Bay. Accurate geochronology is required to determine the timing and tectonic significance of the emplacement of these high grade complexes. A post-tectonic fluorite granite southeast of Chesterfield Inlet has a U-Pb zircon age of approximately 1.83 Ga. The zircons have an inherited, probably Archean, Pb component. The age of low-grade volcanic and sedimentary rocks of the Rankin Inlet Group, previously interpreted as Archean on the basis of lithology and geochemistry, has been confirmed by U-Pb zircon geochronology. A preliminary age of 2.62 Ga has been established for a felsic volcanic rock from the group.

Samarium-Neodymium crustal residence ages from several parts of the central District of Keewatin indicate the presence of extensive Archean crust and lithospheric upper mantle with primary ages older than 2.9 Ga. This indirect evidence for old crust is supported by a U-Pb zircon crystallization age of 3.35 Ga obtained from foliated graniodiorite SW of Baker Lake. Ion microprobe analyses of zircon from this granodiorite at Australian National University confirmed the 3.35 Ga age obtained by conventional U-Pb dating. It also determined the presence of younger zircon grains with ages of about 2.7 and 1.8 Ga. These two ages represent major regional tectonic events that resulted in new zircon growth. The granodiorite is part of a granitoid gneiss complex that is in tectonic contact with metasedimentary and metavolcanic rocks of the Archean Ketyet Group and is unconformably overlain by rocks of the 1.7-1.8 Dubawnt Group rock.

Trace amounts of baddeleyite and zircon have been identified in rocks of the PGE-rich Muskox intrusion and in Mackenzie dykes. U-Pb baddeleyite ages from four Mackenzie dykes are tightly clustered between 1265 and 1269 Ma and the age of the Muskox intrusion is 1270 Ma. The results confirm previous geochronologic, petrologic and paleomagnetic studies that link the Muskox with emplacement of the Mackenzie dyke swarm and provide the first precise age for the Mackenzie igneous event. The result is an important constraint in interpreting tectonic processes which result in the emplacement of large dyke swarms.

SUPERIOR-GRENVILLE SECTION

A. Davidson (Head)

Highlights

Work undertaken by the Superior-Grenville Section focuses mainly on regional geologic studies in the Superior, southern Grenville, eastern Churchill and Nain provinces. Currently it includes map compilation and reports for the DNAG volume on the Precambrian Shield.

Mapping of granulite facies rocks of the Ashuanipi complex, eastern Superior Province (west of Schefferville), was completed in 1987. Although considered to be a unique component of the Superior Province by virtue of its high metamorphic grade, the Ashuanipi granulite complex is similar to sedimentary gneiss belts to the west in terms of lithology, metamorphic conditions and age. Accretionary processes were probably important construction of these 2000 km-long belts.

In central Superior Province, preliminary processing of Lithoprobe lines across the Chapleau block of the Kapuskasing structure shows abundant near-surface reflectors that correspond, on initial interpretation, to faults, lithologic layering and high-strain zones at low angles. The west-dipping oblique cross-section model developed from earlier geological studies is supported by these data, as well as by three independent interpretations of the 1988 seismic refraction data. Anastomosing, low-angle, ductile high-strain zones in tonalite gneisses near the amphibolite-granulite facies transition are interpreted as syn-intrusion extensional structures. The Groundhog River block is a fault-fragmented terrane that is lithologically and structurally distinct from the Chapleau block to the south, and may reppresent exposure of a different crustal level.

Geological field work in the eastern half of the Cape Smith belt was completed in 1987. Significant results include: 1) clastic sediments in progressively more internal (northerly) thrust sheets record sedimentological evolution from a continental rift setting to a deep water, oceanic basin environment; 2) a similar and parallel change in the nature of the volcanic and associated mafic intrusive units was documented. In the southern thrust sheets, volcanic rocks consist of rift-fill basalt and rhyolite; thrust sheets at intermediate structural levels are dominated by komatiitic to MORB-like tholeiites interpreted as crust transitional between continental and oceanic; at the highest structural levels, the most internal imbricates consist of sheeted dykes, gabbro sills, pillowed basalt cut by dykes, and mafic-ultramafic cumulates. These units are interpreted to represent part of an obducted and structurally dismembered ophiolite of early Proterozoic age. This is probably the oldest ophiolite so far discovered. One-dimensional finite difference numerical models have been constructed by writing appropriate programs in FORTRAN 77. The programs are innovative in that they allow for incremental crustal thickening (thus modelling thrust-fold belts more realistically than is usually done) and also for concomitant erosion. Results for the eastern Cape Smith thrust-fold belt indicate that: 1) thermal equilibrium occurs during emplacement of km-scale thrust sheets; 2) no 'incubation' period is needed to achieve thermal peak conditions in the belt, based on available P-T and geochronologic constraints; 3) crustal heating in the belt resulted from thermal relaxations during tectonic thickening, uplift and erosion; 4) preservation of inverted thermal structures can occur as a result of emplacement of a relatively hot, thick (more than 15 km) sheet by syn-thermal peak, out-of-sequence thrust faulting.

The first field season of mapping in northern coastal Labrador was carried out in 1987. Supracrustal gneiss and orthogneiss underlie most of the area and, as defined in the Saglek area, can be correlated with units already mapped farther south. The supracrustal rocks include iron formation quartzite, pelitic gneiss, and metavolcanic and ultramafic rocks. This association occurs in part within an essentially intact structural basin. High-quality soapstone was found in the ultramafic rocks.

A project to re-map the north shore of Georgian Bay in the Grenville Province of Ontario was undertaken in 1987 in order to establish if this cross-section of the Grenville Front Tectonic Zone (GFTZ) exposes lithologic or structural features that might help to explain the remarkable array of shallow-dipping seismic reflectors recorded along GLIMPCE line 'J' in Georgian Bay 85 km to the south. Several moderately to shallowly southeast-dipping mylonite and ductile shear zones were identified and provide suitable candidates for reflection horizons. Certain leucocratic gneisses in the northwest part of the GFTZ are likely deformed and metamorphosed equivalents of ca. 1740 Ma rhyolite and epizonal granite exposed northwest of the Grenville Front near Killarney. Gravity modeling suggests that a wedge of low-density rocks like those of the Killarney volcano-plutonic complex extends into the GFTZ for at least 12 km.

Detailed mapping along the northeast coast of Georgian Bay (Ontario MDA, first season) revealed four distinct gneiss associations, all older than ca. 1460 Ma, the age of pre-Grenvillian granitoids that intruded them. This, along with identification of remnants of 1240 Ma Sudbury diabase dykes at least 50 km in from the Grenville Front, suggests that if this part of the Grenville Province was built by accretion of terranes, and that the accretion was completed long before the Grenvillian orogeny.

Mapping in the Great Slave Lake Shear Zone (GSLSZ) was extended northeast of Snowdrift River into the Schist and Daisy Lakes area. Mylonites, previously identified to the southwest continue to northeast of Snowdrift River as a 15 km-wide belt trending north-northeast. Early strike-lineated, upper amphibolite facies mylonites are flanked to the southeast by younger dip-lineated, granulite facies mylonites. This structural and metamorphic configuration of the GSLSZ is identical to that described for the southern part of the Thelon Tectonic Zone, and the two are therefore considered to belong to the same large-scale structure.

SPECIAL PROJECTS SECTION

Highlights

A comprehensive synthesis of geological and geochronological data documenting the Early Proterozoic assembly of Laurentia was prepared for publication in the 1988 Annual Review of Earth and Planetary Sciences. The northern part of Laurentia, including the Canadian Shield, is a product of the confluence of at least six Archean microcontinents between 1.95 and 1.80 Ga. Juvenile crust was accreted to southern and southeastern Laurentia between 1.80 and 1.65 Ga. The west is composed of 2.0 to 2.3 Ga crust accreted to Laurentia between 1.90 and 1.70 Ga. Early Proterozoic assembly was followed by Middle Proterozoic bimodal anorogenic magmatism, manifesting a mantle superswell possibly caused by thermal insulation by an Early Proterozoic supercontinent of which Laurentia was the largest rifted fragment.

The geological mapping and subsurface studies of Hudson Bay Basin and adjacent areas of Foxe Basin and Hudson Strait continued. This work has resulted in the discovery of Cretaceous (sand/shale facies) deposits in central Hudson Bay (previously unknown) and in deeply subsided sub-basins (in excess of 2 km) beneath Foxe Channel, Evans Strait, and at several localities beneath Hudson Strait. Subsurface studies using industry deep reflection seismic data have enabled the mapping of a complex fracture framework, and the widespread effects of salt solution, both factors being important to any future oil and gas exploration.

Final reports of GSC work on the Troodos ophiolite of the Cyprus Study Project highlighted 3 principal conclusions:

1) Chemically the sheeted dykes of the Troodos Complex match both the associated pillow lava and plutonic successions and have characteristics which are attributable to at least two mantle sources and to fractionation in more than one penecontemporaneous magma chamber.

2) Mineralogical and chemical alteration of the dykes are consistent with their origin at an oceanic or back arc spreading ridge; actinolite facies metamorphism accompanied by loss of CaO and gain in alkalis can be attributed to, interaction with diminishing amounts of sea water that was conditioned by earlier reaction with overlying pillow lavas, and to rising thermal levels induced by the plutonic complex below.

3) Detailed cross-pillow compositional variation from a number of stratigraphic levels in the Troodos Upper Pillow Lavas records a history of prolonged cold seawater circulation, on which appears to be imposed a superficial hydrothermal event. The latter is interpreted as a hydrothermal pulse related to development of the umber deposits which mark the upper contact of the ophiolite.

The Canadian Continental Drilling Program saw substantial progress in 1987-1988. The programme was announced nationally, and a call for proposals issued in May 1987. By December 1987, 29 conceptual proposals have been received, 9 of which came from GSC scientists. There was a wide range of topics suggested, including drilling in the Kapuskasing Structural Zone, in major faults, add-on drilling to sample basement in key areas underlying the Western Sedimentary Basin, and drilling as a means of addressing outstanding problems associated with greenstone belts. A series of thematic workshops is planned, at which proposals or groups of proposals, will be presented and discussed. The first workshop, held in February 1988, concerned the problems to be addressed by research drilling and results from the Lithoprobe transect, in the Kapuskasing Structure.

GEOCHRONOLOGY SECTION

O. van Breemen (Head)

Highlights

Improvements in U-Pb zircon analyses with further streamlining of data reduction continue to be reflected in output so that this year 960 zircon fractions have been analyzed with minimum zircon weights averaging 0.004 mg. Lowest Pb blanks are around 5 picograms. Extensive dating projects are now being initiated which were not previously possible. These include ca. 100 gram samples of basement drill cores from beneath the Alberta Basin yielding ages from 1750 Ma to greater than 2600 Ma, forming coherent age provinces with Archean rocks known only in southern Alberta (ca. 100 analyses). Analyses (75) of single zircon xenocrystic grains from a large number of kimberlites of the Arctic Islands, British Columbia, the Rocky Mountains and elsewhere show that almost all zircons in

kimberlites are xenocrysts and correlate well with the ages (predominantly 1.9-2.1 Ga or older than 2.5 Ga) of rocks of the underlying crystalline basement known from the drill core study and from extrapolations from exposed shield areas to the northeast.

In the southern Thelon Tectonic Zone, N.W.T., the eastern limit of Slave Province type basement has been precisely defined while to the south, the eastern limit of the Proterozoic Taltson Magmatic Zone has been identified. Igneous rocks from the Labrador Trough are ca. 1883 Ma, being the same age as the Molson dykes, Fox River Sill and other mafic rocks in the Circum-Superior region. Granitic igneous rocks from Cape Smith are generally slightly younger at 1860-1840 Ma. The base of the Richmond Gulf sequence is ca. 2100 Ma old.

U-Pb dating of felsic volcanic rocks in the Kaminak Lake area, District of Keewatin, demonstrates that volcanic activity occurred over the entire length of the Rankin-Ennadai Belt between 2690 Ma and 2700 Ma. Continuing conventional (and ion probe) studies of the Ashuanipi gneiss terrane in northern Quebec has confirmed that granulite facies metamorphism in this area is distinctly younger (by about 25 MaO than Kenoran deformation and metamorphism in the Abitibi Belt to the south and is apparently unrelated to it. The data, however, strengthen the correlation between the Ashuanipi and the Quetico Belt, 2000 km along strike to the west where similar ages have been obtained for granulite facies metamorphism and pegmatite intrusion.

Continued U-Pb geochronologic studies of granitic rocks in the Miramichi terrane, New Brunswick, demonstrate 3 periods of plutonism: Middle to Late Ordovician (448-464 Ma), Silurian (414-424 Ma) and Devonian (ca. 392 Ma). Xenocrystic zircon (conventional and ion probe U-Pb analyses) and common Pb isotopic analyses on feldspar from the granites indicate a Precambrian upper crustal source for the magmas. Field studies in the Yukon Tanana terrane of central and western Yukon Territory, combined with U-Pb geochronology have demonstrated that magmatism in the areas is distinctly episodic, with major pulses at 365-345 Ma and 210-185 Ma, and a locally important and previously unrecognized pulse at 265-255 Ma. Elsewhere in the Yukon, the Tombstone plutonic suite is ca. 91 Ma old. Pb and Sr isotopic analyses of Late Cenozoic volcanic rocks throughout British Columbia indicate that the asthenospheric mantle beneath the Cordilleran margin is the same as the mantle source for seamounts in the northeast Pacific Ocean basin.

J.C. Roddick spent six weeks at the Research School of Earth Sciences, Australian National University, using and assessing the application of the ion microprobe to U/Pb dating on samples currently under study at the G.S.C. These high resolution analyses were particularly enlightening on the complexity of growth in zircon and some difficult problems of zircon over-growth were resolved which could not have been resolved by single zircon analysis. For example, measurements on two samples from Proterozoic granulites from the Thelon Tectonic Zone defined both the igneous ages of the protoliths and the times of multiple metamorphic overgrowths. In one case metamorphism apparently extended over 150 Ma, a discovery of considerable tectonic significance.

The U-Pb systematics of monazite are much better known as a result of case studies in British Columbia, and the Himalayas, indicating a closure temperature of ca. 700 C with the result that monazite in some granites retains a memory of prior to the melting stage. This is clearly an important mineral for dating high grade metamorphism. Also of interest was the dating of baddeleyite cores and zircon reaction rims from coronitic metagabbros in the Grenville Province which yielded twofold igneous and Grenville metamorphic ages. It was demonstrated that the U-Pb baddeleyite system like that of zircon can survive granulite facies metamorphism and in this case metamorphic zircon growth was related directly to major mineral growth fabrics.

Rb-Sr analysis is now running routinely and the 40Ar/39Ar line is also in working order having reduced about 10 age spectra on hornblendes and biotites. G.S.C. Paper 87-2 titled "Radiogenic Age and Isotopic Studies: Report 1" has been published. This report is the first in a series of annual collections of short papers, as well as a K-Ar age compilations, presenting analytical results generated by the Geochronology Section.

PALEOMAGNETISM SECTION

W.F. Fahrig (Head)

Highlights

Paleomagnetic study has proven; (a) that the Mackenzie Arc of northeastern British Columbia has a primary origin and is not the result of dynamic bending on the flank of a geosyncline and (b) that the great belt of diabase sheets known as the Nipissing (some of which are closely associated with silver deposits of the Cobalt area) are the results of three distinct intrusive episodes. The rocks of the three episodes have paleomagnetic pole positions suggesting intrusive events separated by tens of millions of years. The first primary paleomagnetic pole for the Late Ordovician-Silurian period in Atlantic Canada has been obtained from strata of the King George IV Lake area in Newfoundland. This pole will be used in future work to determine whether this area of the Appalachians has been displaced relative to the craton since Early Silurian time.

PETROLOGY SECTION

K.L. Currie (Head)

Highlights

A red-bed copper deposit at Canfield Creek, Nova Scotia was deposited on wood debris in river channel sandstones. The reducing environment necessary for metal deposition was thus preserved in alluvial-plain lakes and swamps. Pollen analysis has confirmed the sedimentological environment deductions.

Combination of recent field mapping and a gravity survey in southern New Brunswick shows that the late Precambrian basement (Avalon Zone) steps downward on a series of normal faults to underlie Silurian and younger strata. Each episode of faulting was accompanied by bimodal magmatism leaking up the fault. None of these plutons is penetratively deformed. Therefore Devonian orogeny did not affect the Avalonian continental block, but was apparently confined to narrow troughs between continental or micro-continental blocks. Further, the Avalon block must have been in its present position relative to North America by lower Silurian or earlier time.

Granite bodies in the eastern Meguma terrane of Nova Scotia commonly have small amounts of deformed peraluminous tonalite associated with them. Very precise Pb-U zircon dating showed that all the bodies were intruded in a 10 Ma time span (365-375 Ma), and that emplacement took place contemporaneous with movement on the Cobequid fault, which bounds the Meguma terrane. The granitic bodies appear to lack the "specialized" high-silica mineralized facies found further west.

The late Precambrian Fourchu Group of southeastern Cape Breton Island consists of two lithologically distinct belts of basaltic volcanics. The belts are intruded by late Precambrian differentiated plutons, and an uncertain number of young (Devonian?) porphyries.

The transition between wackes of the Goldenville Formation and slate of the Halifax Formation of the Meguma Group in Nova Scotia exhibits mineralogy, trace fossils and clastic sedimentology suggestive of the death of a submarine fan complex due to cut off of oceanic circulation and onset of anoxia. The rocks in the transition are strongly mineralized with Mn and Zn.

A model was constructed for Fe-Mg mixing in garnet, and applied to geothermometers using coexisting garnet and another Fe-Mg mineral. The use of this model, together with an internally consistent data base, significantly improves the accuracy and precision of exchange geothermometers.

New age data permit refinement of the model for development of the Stellarton graben of northern Nova Scotia. Alluvial fan sedimentation north of the graben persisted during early stages of fluviolacustrine infill of the graben. Detailed sequence analysis of the Thorburn Member shows strong cyclic sedimentation (open lake-delta progadation-peat accumulation-open lake). Similar sequences characterize older coal-bearing strata. Facies analysis of the coal seams shows that peats accumulated under fluctuating limnic to wet forest swamp conditions, as shown by analysis of the spore data. Each seam is petrographically distinct.

Careful geochemical and geochronological investigation of the volcanics of the Bathurst camp, New Brunswick, show that they can be separated into rift-transitional and ocean floor sequences which were subsequently telescoped during the closure of a small ocean or marginal sea. The Fredericton trough to the south probably represents a Silurian fore-deep associated with the closure phase of this system.

High precision zircon dating shows that much of the igneous activity north of the Catamaran fault in the Central Plutonic Belt of New Brunswick is Silurian, not Devonian as previously thought. The Devonian over-print on K-Ar and Rb-Sr ages appears due to metamorphism and lteration associated with emplacement of mid-Devonian mineralized specialized granite. The Silurian granites are transitional from I-type to A-type, but do not appear to have a high economic potential.

High precision zircon dating south of Grand Lake, Newfoundland shows that rocks east of and along the Long Range fault have been affected by mid-Ordovician and younger granulite facies metamorphism and their ages are completely reset. Therefore continent-continent collision must have occurred in this region by mid-Ordovician time. The slivers of ophiolite in the high-grade rocks are not part of the allochthonous Dunnage Zone, but possibly relicts of an old continental break-up.

Detailed electron probe examination of metamorphic minerals in the File Lake area of Manitoba, combined with geothermometry, geochronology and one dimensional heat-flow modeling indicate that slow uplift models (0.6 km/Ma) are plausible.

Structural studies in the Thompson Belt of Manitoba indicate upward movement of the Superior province relative to the Churchill Province.

Petrographic studies of the Kisseynew gneiss north of Amisk Lake, Saskatchewan demonstrate continuous metamorphic zonation, supporting earlier field mapping evidence that the Kisseynew gneisses form a metamorphic equivalent of the Flin Flon volcanic belt.

Petrographic studies of metamorphosed alteration zones near Snow Lake, Manitoba show consistent phase relations among silicates, sulphides and oxides. The systematic variation of phase assemblages and the common occurrence of gahnite indicate that metamorphic assemblages probably reached equilibrium, and that the sulphide deposits are therefore metamorphic deposits.

SEISMOLOGY AND ELECTROMAGNETISM SECTION

A.G. Menzel-Jones (Head)

Highlights

This section is responsible for crustal studies using an integrated multidisciplinary approach involving various geophysical methods and research along with geology. During 1987 in the Trans-Hudson Orogen, a magnetotelluric field programme was undertaken in Saskatchewan to delineate further the enigmatic North American Central Plains (NACP) conductivity anomaly and its correlation, if any, with the Trans-Hudson Orogen. Two profiles, of a total of thirty-five (35) ten-component MT sites, were made at latitudes of ∿51°N and ∿53°N, and the interpretation of these data, coupled with those obtained from thirty-five (35) MT sites recorded just north of the U.S./Canadian border, is being undertaken. A paper on the qualitative aspects of the MT data, and another paper on a coordinated interpretation of the geophysical data available along a profile just north of the U.S./Canadian border, were presented at the IUGG meeting (August, 1987). The MT data infer the presence of a major sinistral strike-slip fault in the basement beneath the Phanerozoic sediments of the Williston Basin. These two pieces of work have been combined into a single manuscript which has been submitted for publication.

The electromagnetic group is in consultation with Phoenix Geophysics Ltd. (Toronto) regarding Phoenix's new V5 multi-purpose receiver developed via IRAP/PILP (Program for Industry/Laboratory Projects). It is capable of multichannel data collection for currently audiomagnetotelluric, magnetotelluric, and controlled source EM measurements. Extension to other techniques would simply require reprogramming the controlling EPROMs. Joint field tests have been conducted combining our recently-acquired instrument with one belonging to Phoenix. The commercial success of this technology transfer for this group - in this case information technology - to Phoenix has already been outstanding in the short two months since the V5 became commercially available. Phoenix has delivered two systems, worth $1M, to Japan, and they have other orders and many other interested buyers.

In the GLIMPCE Project, the joint GSC-USGS geophysical investigations of the Great Lakes region, more than 1300 km of GLIMPCE deep seismic reflection data have been migrated using LCSD's processing facilities. A first paper focusing on the deep structure of the Mid-Continent Rift System in Lake Superior has been published in "Geology", a second paper has been accepted for publication in "Geology" and a third paper has been submitted for publication. The application of recently developed processing, imaging and migration techniques proved to be essential in order to obtain high quality seismic images of key geological targets (e.g. the Grenville Front). Phase 2 processing of GLIMPCE data is focusing on true amplitude and pre-stack migration techniques with a view to obtaining improved images of critical structures (e.g. Keweenawan and Isle Royale faults and several unconformities) in the Lake Superior data.

For the Trans-Alaskan Crustal Transect (TACT) section scientists planned and supervised GSC's participation in the USGS sponsored refraction experiment in ALASKA. Using the new PRS hardware we were able to produce record sections in the field and give the USGS estimates of crustal thickness within hours of a deployment. The demonstration of the PRS hardware and sofware, originally developed at the Instrumentation Lab of the Geophysics Division, convinced the USGS to purchase the product which is now commercially available from EDA Ltd. (Toronto) through an IRAP/PILP technology transfer.

A highly successful workshop, that focused on the reprocessing, remodelling and reinterpretation of LITHOPROBE and FGP seismic reflection and seismic refraction data, collected from Vancouver Island and adjacent offshore regions, occurred in Whistler during August. The workshop was sponsored by the IASPEI Commission on Controlled Source Seismology and was organized jointly by personnel from the Geological Survey of Canada and the University of British Columbia. More than 46 scientists from 13 countries attended the Workshop. There were representatives from universities, government agencies and the seismic processing industry. Written papers based on contributions to the workshop are currently being reviewed externally with the intention of publishing the proceedings as a Geological Survey of Canada Paper or Open File Report.

The PRS-1 portable seismic refraction instrument was originally developed at the Instrumentation Lab of the Geophysics Division in consultation with section scientists. The technology was then transferred to EDA Ltd. (Toronto) through an IRAP/PILP. However, initial field tests with EDA's user-interface software illustrated that major revisions were required. Therefore, two section scientists headed a software team of six who have, over a six month period, totally re-written the user-interface in accordance with modern coding standards. Version 1 of the menu-driven user-friendly seismic lunchbox software is now in the B-test stage, and has been distributed to approximately 10 institutions for feedback. The new software offers refraction seismologists the opportunity to produce final sections from an experiment in days/months rather than years as was currently the case. This new software will make the PRS-1, and its four component version the PRS-4, a much more attractive product, and accordingly will increase greatly the commercial success of EDA Ltd. We understand that EDA has recently received an order worth $700K from Japan for PRS-4's.

Along with Prof. D.W. Oldenburg, of UBC, sector scientists have submitted a paper describing qualitatively the results of the highly successful contracted MT survey across the LITHOPROBE seismic lines in S.E. British Columbia. As part of the LITHOPROBE Southern Cordilleran Transect investigations, twenty-seven wide-band magnetotelluric (MT) responses were obtained at nineteen distinct locations along 150 km of the reflection seismic lines. The MT profile begins on the east near the Rocky Mountain Trench above autochthonous North American basement, which is overlain by deformed and transported cover, traverses across the Purcell anticlinorium, the Kootenay Arc, the Nelson batholith, and ends on the east side of the Valhalla gneiss complex west of the Eocene Slocan Lake normal fault. These MT data are of excellent quality, allowing direct comparison with the structural information revealed by the seismic reflection survey. Stations close to Kootenay Lake respond to a major near-surface conductivity anomaly that is probably due to either graphitic schists or to an extension of the silver-bearing mineralization found further north in the Bluebell Mine. The data across the Nelson batholith are highly complex and exhibit 3D regional features that are beyond current abilities of numerical programmes to model. However, the data from the two sites on the Valhalla complex are reasonably 1D. Inversions of these data yield 1D models that, when compared with the seismic reflection results, indicate electrical structure in the region marked as of uncertain seismic interpretation by Cook et al. (1987, 1988). Interfaces in electrical conductivity are found at depths that agree with an increase in the number of reflectors at ∿9 km, "the base of layered reflections" at ∿22 km, and the Moho at ∿35 km. Of major significance to our understanding of the current composition and state of the lower continental crust is that although for the Valhalla complex there are few reflections below ∿8 s the MT responses indicate that the zone is conducting. This is the only location known to the authors where the lower crust is seismically transparent but electrically conductive.

After more than three months of seismic reflection surveying under environmentally hostile conditions, which included thunderstorms in October and extreme cold in early January (-40 degrees C), more than 300 km of regional data (50 m recorder spacing, 12-52 Hz) and 18 km of high resolution data (20 m recorder spacing, 20-130 Hz) were collected across the Kapuskasing Structural Zone. At two locations the important Ivanhoe cataclastic zone is imaged as a major westward dipping reflection zone, in general agreement with the thrust model first proposed by Percival and Card. Based on preliminary processed sections, the cataclastic zone appears to flatten at relatively shallow depths and there is a suggestion in the deeper parts of the data of a "flat and ramp" geometry. Surprisingly strong and continuous bands of reflections are recorded beneath the Shawmere anorthosite and beneath the enigmatic Ground Hog River block. Beneath the latter structure the strong reflections extend from the surface to the base of the crust at roughly 14 s two-way travel time. Perhaps one of the most important results of the survey is the conclusion that certain types of gneissic rock may be a common source of layered reflections from the deep crust, with reflections originating at lithological boundaries and mylonite zones within the gneisses.

As a result of significant contributions from the Provincial Governments of Quebec and Ontario and a smaller contribution from a Quebec-based mining company, LITHOPROBE has acquired seismic reflection data from the Abitibi granite-greenstone belt. Approximately 130 km of regional data and 64 km of high resolution data were collected along three profiles that crossed the important gold-bearing Procupine-Destor and Cadillac faults and the mineral-rich Blake River volcanic sequence. The regions to the south of both faults have produced some of the most spectacular reflections observed in the LITHOPROBE program. The high resolution sections are particularly impressive. For the first time it is possible to state with some confidence that the Cadillac fault near Rouyn-Noranda dips steeply to the north (its regional attitude has been the subject of considerable controversy in the past). The seismic reflection method thus shows considerable promise as a new tool for the mineral exploration industry.

Using the Polar Continental Shelf Project Ice Island base camp in 1985 and 1986, the Lithosphere and Canadian Shield Division, in cooperation with scientists from the Institute of Sedimentary and Petroleum Geology and the Arctic Geoscience Centre, conducted the most detailed Arctic crustal refraction surveys to date north of Axel Heiberg Island. The Ice Island refraction studies delineate a major sedimentary basin at least 10 km thick off Canada's northeast polar margin that was probably formed as a result of the opening of the Arctic Ocean during the Mesozoic Era, some 100-200 million years ago. The results of these studies show that the sedimentary basin is bounded on its continental edge by a major down- to-basin fault system similar to that of the hydrocarbon rich Beaufort-Mackenzie basin. The refraction models and the potential field anomaly data (see below) are providing estimates of the supracrustal architecture of a heretofore unknown area of the Canadian polar continental shelf that will form the basis of any major hydrocarbon exploration programs in the region for decades to come. These results are mapping the complex structure of the continent-ocean transition. They are also providing constraints on the nature of the continental rifting that preceded the opening of the Arctic Ocean and the subsequent seafloor spreading and development of the present Arctic margin. These data, combined with other geological and geophysical data from the Ice Island, adjacent onshore and circumpolar surveys, are forming the basis of a multidisciplinary approach to understanding the origins and evolution of the Arctic Ocean. The 1985 Ice Island refraction paper has been completed, approved, submitted and is under review by Canadian Journal of Earth Sciences.

POTENTIAL FIELDS SECTION

M.D. Thomas (Head)

Highlights

A new type of gravity map, an enhanced residual anomaly map, was developed as a by-product of crustal studies in the Arctic. It is based on relationships between residual isostatic gravity anomaly and elevation (or rock-equivalent depth in the ocean), derived separately for land, continental shelf, continental slope and rise, and deep ocean. This type of gravity anomaly map enhances variations in gravity related to geological structure, and essentially eliminates those variations related to water-rock interfaces and topography/bathymetry and associated isostatic roots/antiroots, which may be present in more conventional Bouguer, free-air and residual isostatic anomaly maps.

The enhanced residual map may prove to be a useful reconnaissance tool for delineating Arctic regions with hydrocarbon potential. This is suggested by correlations between regions of negative anomalies and areas designated as having high potential for hydrocarbons, such as the western Sverdrup basin and Mackenzie Delta. Potentially barren regions, on the other hand, such as the northeastern Sverdrup Basin, which is associated with mafic volcanic rocks, are characterized by positive anomalies.

A GSC Open File report on "Geophysical Imaging Software for IBM-Compatible Microcomputers" was released in August and was enthusiastically received by a wide cross-section of geoscientists in Canada, the U.S.A. and a number of other countries world-wide.

Detailed gravity surveys were completed in southeastern British Columbia and along the northern and eastern shores of Georgian Bay in conjunction with structural studies related to Lithoprobe Southern Canadian Cordilleran Transect and the Great Lake International Multidisciplinary Program on Crustal Evolution (GLIMPCE), respectively. Surveys were carried out in association with the Geophysics Division. Preliminary gravity modelling of this traverse across the Grenville Front along the shores of Georgian Bay indicates that the Killarney Granite, exposed in a narrow belt north of the Front, has a geometry that conforms to certain strong reflectors observed in an offshore GLIMPCE seismic reflection profile conducted along strike in Lake Huron. By comparison it is inferred that the Grenville Front on shore dips to the southeast forming the southeastern boundary of the Killarney Granite. The bottom of the granite is modelled at a depth of about 16 km, at which depth a strong sub-horizontal reflector is observed in the offshore seismic record. Gravity modelling also indicates that a zone of mixed Killarney-type granite and gneiss and Huronian metasediments immediately south of the Front is restricted to a shallow depth of about 5 km.

Studies of vertical gravity gradient maps of the Quoich River area of the northwestern Churchill Province, supplemented by other potential field data and structural mapping, suggest that the Amer and Wager Bay shear zones may have developed along the opposite margins of a pre-existing linear structure. This is the first indication that these two shear zones have a genetic link.

MINERAL RESOURCES DIVISION

J.M. Duke

The Division is responsible for: providing a comprehensive knowledge base on the nature and distribution of Canada's mineral resources; developing concepts and technologies to aid Canadian industry in the search for new resources; providing scientific and technical support for resource management and land use planning; providing compositional analyses of geological materials; and developing methodologies and establishing standards relevant to the above.

To carry out these responsibilities, the Division is organized into an Administrative Unit and four Subdivisions: Mineral Deposits; Mineralogy and Chemistry; Exploration Geophysics; and Exploration Geochemistry. The objectives and roles of individual units and highlights of their activities are presented under the relevant headings on the following pages.

The Division has a staff strength of 153 person years with an additional 14.5 person years in term positions that are assigned to activities in Federal Initiative programs in Quebec and various Mineral Development Agreements.

In 1987-88, the Division supported 16 EMR Research Agreements and 86 outside research contracts.

Division Office and Administration

This unit, comprising the Director, Assistant, Secretary, Staff Scientist, Administrative Officer and four Financial Clerks, manages the Division's activities and resources and provides general administrative, financial and personnel support for the Division. One Special Projects scientist conducts geophysical studies and monitors and reports on new geophysical technology and methodology relevant to the exploration/ mining industry.

Special Projects

A planning mission to Zimbabwe was undertaken on behalf of CIDA for the second phase of an aeromagnetic survey program for the Geological Survey of Zimbabwe.

The Magnetic Map of North America, a DNAG contribution compiled at the GSC, was printed by the USGS in July and was displayed for the first time in Vancouver at the International Union of Geodesy and Geophysics in August and subsequently at meetings in New Orleans, Ottawa and Toronto.

Personnel Notes

D.C. Findlay, Director of Economic Geology Division 1983-84, Economic Geology and Mineralogy Division, 1984-86, and Mineral Resources Division 1986-87, was appointed Director General of the new Continental Geoscience and Mineral Resources Branch in September. **J.M. Duke** was named Director-designate in December and began French language training in February. **A.G. Plant** served as Acting Director commencing in January.

P.J. Hood transferred from Geophysics Division in July as a Special Project officer.

M.M. Redden resigned from the Public Service in July after 12 years, chiefly as Subdivision and Division secretary. Her replacement, **D. Bouchard**, was appointed Branch secretary, and **L.L. McGuire** became (acting) Division secretary in January.

R. MacKenzie joined the Administrative and Financial Services unit in April from Surveys and Mapping; **A. Moncion** provided term support for part of the year.

Mineral Deposits Subdivision

R.F.J. Scoates, Head

The mission of the Mineral Deposits Subdivision is to provide comprehensive geological knowledge concerning the nature, distribution and origin of Canada's nonhydrocarbon mineral resources. This knowledge is intended to assist the private sector in mineral exploration and government in policy formulation. To meet this responsibility, the subdivision has designed a program which includes three main elements:

1. Mineral Deposits Studies: Both mineral exploration and resource assessment endeavour to predict the location, size and quality of undiscovered mineral deposits. This presupposes an understanding of (a) the attributes of various types of mineral deposits, and (b) the reasons why deposits occur where they do. To contribute to such an understanding, the subdivision carries out comprehensive field and laboratory studies of selected deposits, characterizes the essential attributes of related deposits, and investigates ore-forming processes using such techniques as thermodynamic analysis, radiogenic and stable isotope geochemistry, structural analysis and so on.

2. Regional Metallogenic Studies: Different geological terranes are characterized by different assemblages of mineral deposit types. An understanding of the relationship between mineral deposits and their geological setting is fundamental to the prediction of what types of deposits are likely to occur in a given region. Consequently, the subdivision undertakes regional metallogenic studies which integrate the broad range of geological, tectonic and metallogenic data in selected regions of Canada. These studies provide guidelines for mineral exploration as well as for mineral resource appraisal.

3. Mineral Resource Assessment: The department is required to provide annual assessments of Canadian reserves and resources of uranium and thorium. The subdivision contributes data on resources, exploration activity, geological deposit models, and exploration technology to the annual URAG (Uranium Resource Appraisal Group) process which are released as the biennial reports of the Department (Uranium in Canada; Assessment of Supply and Requirements). The subdivision is also required to evaluate resources of specified regions or commodities in Canada on an 'on demand' basis. These evaluations are carried out at the request of other government agencies such as the Department of Indian and Northern Affairs, Parks Canada, and the Department of External Affairs and are used as the basis for land use planning, the delineation of national parks, aboriginal land claims negotiations, international boundary disputes negotiations, and the like.

The subdivision includes five research sections which are Mineral Deposits Geology, Geochemistry of Mineral Deposits, Northern Minerals, Southern Minerals, and Mineral Resource Appraisal Secretariat. In addition, the subdivision operates two service units in support of its research and other activities. The Mineral Resource Information Services Unit ensures the availability of mineral deposits data in both electronic and traditional form. This unit maintains the GSC developed CANMINDEX system and acquires and makes accessible electronic data bases from provincial and other agencies. The Laboratory and Scientific Support Unit is responsible for processing rock specimens, preparation of polished sections, mineral separations, maintainance of the research microscopy laboratory, and certain drafting requirements.

Highlights

Platinum-group elements

In mineral deposits research the Division continued its focus on platinum-group elements (PGE) and gold. Evidence from Canada-wide studies of massive and semi-massive nickel-copper sulphide occurrences suggests that PGE-enriched sulphides are associated with intrusions that had relatively high PGE concentrations in the initial magma(s). Detailed studies in the Fox River Sill, Manitoba imply an affiliation between PGE mineralization and clinopyroxene-rich layers. Sulphur isotope data indicate that the PGE are associated with sulphides that contain a significant proportion of non-mantle sulphur. Computer modelling of the behaviour of Pt in hydrothermal fluids suggests that redox fronts in sedimentary sequences and serpentinization fronts in mafic/ultramafic rocks are the most favourable environments for hydrothermal concentrations of Pt. A potentially new type of hydrothermal platinum deposit has been identified at Fish Hook Bay, Saskatchewan. This association of Pt with bismuth selenides is further evidence of the association of Se with PGE as reported last year.

Gold

Studies of gold deposits and gold metallogeny have focused on detailed structural observations, fluid migration and isotopic signatures. In the Val D'Or district of Quebec, geometries of auriferous veins and strain patterns in regionally deformed volcanic rocks both reflect regional north-south shortening and vertical elongation. The formation of mineralized structures simply represents one of the last increments of regional deformation. In studies of major faults in three areas of gold mineralization in southwestern Shield (Laronge Domain, Saskatchewan, Archean Rice Lake Belt, Manitoba and Mine Centre, Ontario) gold is associated with second and third order subsidiary shear zones which are kinematically compatible with the large faults. Replacement pyritic gold ores in marbles at the Mosquito Creek Gold Mine, British Columbia, are syntectonic rather than syngenetic, and gold-bearing veins previously considered to represent channelways for fluid circulation and infiltration in the marbles are in fact cutting across replacement ores. Gold mineralization in the Courageous Lake area, central Slave Province is concentrated within quartz veins and as disseminations in structurally favourable sites within a variety of volcanic and sedimentary rocks. In the Schultz Lake area, District of Keewatin, Archean gold mineralization is concentrated in three distinct geological settings.

Sulphur is much better than arsenic as a guide to gold and high K_2O/Na_2O ratios in host rocks may indicate hydrothermal alteration in vein controlled gold mineralization in the Meguma Group of Nova Scotia. A new technique for determining the age of Precambrian gold deposits has been developed using the Sm/Nd radioactive decay system in scheelite from gold-bearing veins in the Timmins area. Sr and Nd initial isotopic ratios indicate that the fluids responsible for gold deposits originate in both the lower crust and the mantle. This method offers considerable promise for determining the age of gold deposits, thereby providing temporal constraints on genetic models. The highest gold grades at the Skukum gold-quartz vein deposit, Yukon, are associated with boiling at a uniform distance below the present surface. Recent geological studies have shown that boiling occurred because of a pressure decrease where the fault controlling fluid discharge cut a highly permeable pyroclastic unit. This discovery has opened up new targets at depth where permeable units are cut by faults and associated gold-quartz veins. Lithogeochemical and mineralogical studies of gold-silver occurrences in the Mitchell-Sulphurets area, British Columbia indicated potential for large, low grade, bulk-mineable deposits. The precious metals appear to be associated with a large, deformed porphyry copper-molybdenum deposit. Four vein-gold deposits, in the Chaoyang area of northeast China examined under the Canada-China Memorandum of Understanding are hosted by high grade gneissic Archean basement, and resemble Mesozoic gold deposits of the Canadian Cordillera.

Tin, tungsten, molybdenum

Tin and tungsten-molybdenum deposits at Mount Pleasant, New Brunswick are associated with at least three distinct subvolcanic granitic intrusions near the southwest margin of the Mount Pleasant caldera. The intrusion related to tin deposits in the North Zone contains abundant fluid saturation textures such as comb quartz layers and miarolitic cavities indicating that a significant proportion of the mineralizing fluids were magmatic.

Lead, zinc

Periods in the Paleozoic when the oceans were stratified with anoxic, sulphidic bottom waters have now been traced from the Selwyn Basin where they were first documented to the Blackstone Trough, Richardson Trough and Artic Islands. Because an ambient water column containing dissolved sulphide is essential to the formation of sedimentary Pb-Zn deposits, the identification of anoxic events in sedimentary basins other than the Selwyn Basin has increased the potential for Pb-Zn mineralization.

Seafloor minerals project

In the Seafloor Minerals Project, initial grid-coring of the Middle Valley sulphide zone revealed many sulphide layers in the upper 5 metres, with more massive sulphide at the base of most cores. The deposits contains about 1 million tonnes of sulphide per vertical metre. A unique high-temperature smectite is associated with the mineralized area and can be used as a regional indicator of mineralization. Study of the only alteration pipe yet discovered beneath a seafloor massive sulphide deposit at Galapagos, reveals that advected cold seawater is by far the most important influence in forming the chlorite-smectite zone.

Regional Metallogeny

In regional metallogenetic studies newly discovered, undeformed, multi-element (including rare metal) - bearing alkalic intrusions in McLeod Bay, East Arm of Great Slave Lake resemble the Blatchford Lake Intrusion. Late Proterozoic strata of Mackenzie Mountains and Victoria Island have been correlated on the basis of lithology and stromatolites with implications for phosphate, minor iron formation and Pb-Zn prospectivity.

Metallogenic studies in the western Cape Breton Highlands, Nova Scotia, have defined the age and stratigraphic framework for the auriferous Jumping Brook metamorphic suite, permitting correlations with other volcanic suites and indicating potential new exploration areas. A previously unrecognized Au-Te-Bi association has been identified in many occurrences which are currently being explored intensively. Lead and sulphur isotopic analyses and bulk chemistry of carbonate-hosted zinc deposits indicate that they occur within a Grenville Supergroup age equivalent suite which is probably basement to much of Cape Breton.

Mississippi Valley-type lead-zinc

Thermal history studies in major North American Mississippi Valley-type lead-zinc districts have shown that, contrary to previous concepts, the deposits do not constitute thermal anomalies relative to their host rocks. Preliminary interpretation of the data do, however, reveal that both host rocks and ore represent temperatures exceeding those expected from paleostratigraphic reconstructions and point to widespread

flooding of platform carbonates by hot mineralizing brines.

Resource Assessment Studies

In northern mineral resource assessment (MERA) the Division has completed assessment of the Banks-Victoria Islands area and high uranium and moderate to high lead-zinc potential have been given to parts of the proposed national park area. In the Nahanni Park Extensions area assessment work has revealed anomalous tungsten and molybdenum in hot spring waters of granitic terrain, anomalous gold in the streams draining Devonian shales and carbonates in Nahanni Karst, and polymetalliferous hot springs in the Tlogotsho Plateau area.

Canadian uranium resources in measured, indicated and inferred categories, recoverable at prices up to $100/kg U, increased during the two year period by 10.5 percent. A new genetic model for basal-type uranium deposits in the Beaverdell area (Blizzard Deposit) indicates a previously unrecognized, strong stratigraphic control of uranium mineralization.

CANMINDEX

One of our most important resources is information, a resource which modern micro- computers have brought closer to more people than at any time in the past. GSC's index to Canadian mineral deposits, the CANMINDEX database, has been adapted to microcomputers, thereby rendering these data more easily accessible to Survey researchers, and at much reduced cost.

Personnel Notes

The Mineral Deposits Subdivision consisted of 27 Research Scientists, 21 Physical Scientists, 3 Support Staff and 3 Clerical Staff. Of these, three Research and nine Physical Scientists were associated with Federal-Provincial Mineral Development Agreements.

R.F.J. Scoates replaced J.M. Duke as Head, Mineral Deposits Subdivision, effective February 1, 1988. **N. Cox** and **S. Pollock** completed their terms of employment with the Subdivision. **Winton Cornell** began a Visiting Fellowship with B.E. Taylor in January, 1988, and **Debora Wood** took up secretarial duties in Subdivision office in March, 1988. **C.D. Anglin, K. Baker, R. Bretzlaff, C. Collins, Q. Gall, J. Ketchum, L.E. Koopman** and **Z.D.G. Richardson** provided term scientific and secretarial support. **S.A. Scully** is on a one year leave-of-absence. **Scott Swinden** resigned and took a position with the Newfoundland Department of Mines and Energy.

Exploration Geophysics Subdivision

K.A. Richardson, Head

The objectives of the Subdivision are to develop and demonstrate new geophysical measurement techniques and their applications to mapping, mineral deposits research, mineral explortion, engineering geology, and environmental concerns; to provide standards and calibration facitilites for geophysical meausrements; to provide a comprehensive, systematic geophysical database for use by government and industry; to provide a nuclear emergency response team, having the expertise and equipment to minitor radiation released due to nuclear accidents; and to provide to the Sector mechanical services for instrument development.

The Subdivision comprises 5 sections: Airborne Geophysics, Borehole Geophysics, Electrical Methods, Instrumentation R & D, and Technical Services.

Goals for the Airborne Geophysics Section include: the improvement of the GSC Skyvan system; conducting surveys for geologic mapping purposes and for determination of geophysical signatures of mineral deposit types; development of data presentation and interpretation, publication of radioelement maps; and carrying out follow-up investigations. The Borehole Geophysics Section maintains and develops calibration facilities for borehole measurements and tests and develops applications of multiparameter logging to geological problems. The Electrical Methods Section work involves the investigation of applications of ground and airborne electrical and electromagnetic methods to geological mapping and mineral exploration, and includes operation of the physical rock properties laboratory. The Instrument R & D Section is involved in the design, development and evaluation of instrumentation primarily for airborne and borehole geophysical applications. The Technical Services Sections provides service to the Sector in design, fabrication and testing of prototype equipment for laboratory and field applications, and in maintenance and servicing of scientific equipment .

Highlights

In exploration geophysics, the division proceeded with the development of technology and new applications of geophysical techniques.

Instrumentation developments included the implementation of an automatic background monitoring system for the Skyvan gamma-ray spectrometer, the design, fabrication and testing of an inductive borehole conductivity and magnetic susceptibility probe, and the fabrication of an electro-thermal sample vaporizer for inductively coupled mass spectrometry.

The Skyvan system with its new upward-looking background detectors was tested by conducting airborne gamma-ray/VLF/magnetometer surveys in several areas: west of Ottawa; at Gander, Newfoundland; and in southern Nova Scotia and New Brunswick. A contract gamma-ray/VLF/magnetometer survey was flown (under the Newfoundland MDA) in the Great Northern Peninsula of Newfoundland. During the year, radiometric surveys from previous years were compiled and published for approximately 75 1:50,000 scale map sheets in Newfoundland, Nova Scotia, and New Brunswick. The most obvious impact of these surveys on the mineral industry followed the release of maps from the 1986 Bathurst-Campbellton contract survey flown under the New Brunswick MDA. The apparent relationship between the potassium radiometric anomalies and gold/silver mineralization, stimulated a high level of claim-staking in the survey area from November, 1987, to the end of the fiscal year.

The GSC Skyvan was used in the summer of 1987, for flight testing of a new Scintrex airborne gamma-ray spectrometer system which was being delivered to the People's Republic of China. Test flights with this system were carried out over Maniwaki, Quebec, as part of a GSC/DSS-supported Unsolicited Proposal to investigate the relationship between airborne gamma-ray spectrometric measurements and the level of radon in houses.

In borehole investigations, field work in British Columbia in co-operation with Terrain Sciences Division demonstrated geotechnical applications of natural gamma-ray logging combined with the new technique of magnetic susceptibility logging, for interpretation of stratigraphy in the sediments of the Fraser delta. Continuing development of the spectral gamma-gamma (SGG) logging technique showed that SGG measurements in boreholes at the Yava Mine in Nova Scotia and lead analyses on drill core samples gave a correlation coefficient of 0.88, indicating good potential for achieving a borehole heavy metal assay capability.

The new application of electromagnetic methods to mapping of Quaternary sediments was demonstrated in the Timmins-Kapuskasing area. Ground EM follow-up at 75 sites selected from a 1986/87 helicopter EM survey and drilling by Terrain Sciences Division at 26 of these targets, showed that ground and airborne EM can be used to differentiate sediments (clay, till, sand) and to map buried bedrock topography. The subdivision was also involved in preparing specifications, monitoring, and interpreting results of contract airborne electromagnetic surveys in Manitoba (Lynn Lake) and Quebec (Monts Stoke and Gaspe).

International activities in geophysics included the participation of staff members: (i) as borehole logging scientist for Leg 114 of the Ocean Drilling Program from Falkland Islands to Mauritius, (ii) as advisor to CIDA for helicopter EM surveys conducted by Canadian contractors for the Thailand Department of Mineral Resources, (iii) as consultant to the International Atomic Energy Agency for radiometric surveys and calibration in Turkey and Jordan and (iv) as organizer and host for IAEA technical consultants meeting on nuclear techniques in exploration and borehole logging, which was attended by delegates from 12 countries including China, Russia, Australia, United Kingdom and Unites States.

Mineralogy and Chemistry Subdivision

A.G. Plant, Head

The principal responsibilities of the Subdivision are as follows:

1. To provide mineralogical data and professional expertise to support Sector projects by maintaining and developing mineralogy laboratories to include X-ray diffraction and crystallography, electron microprobe analysis, scanning electron microscopy and image analysis.

2. To undertake research studies on selected mineral deposits, on problems of mineralogical terminology and on mineral assemblages to contribute to petrological research.

3. To provide chemical analyses of geological materials in support of Sector projects by maintaining and developing analytical chemistry laboratories, including general chemical laboratory, atomic absorption, ion chromatography, X-ray fluorescence and inductively coupled plasma emission and mass spectrometry laboratories, and by managing contracts with commercial laboratories.

4. To develop analytical procedures to improve the quality and quantity of analytical data reported in the

Subdivision laboratories, to develop methodology for new matrices and for elements not currently determined, and to undertake research in new analytical methodology in cooperation with instrument manufacturers and commercial laboratories.

5. To operate sample preparation laboratories for the preparation of geological samples prior to chemical analysis and to prepare mineral separates and rock samples for geochronological determinations and research studies.

6. To curate and develop the Geological Survey of Canada Rock Collection, the Reference Series of the National Mineral Collection and the National Meteorite Collection.

7. To provide geological information to the Canadian public through the preparation and sale of rock and mineral sets, the free examination of specimens submitted by the public, and the preparation of guidebooks to Canadian mineral areas as an aid to collectors and tourism.

At the end of the report period the Subdivision comprised 4 research scientists, 11 physical scientist, 5 chemists and 27 scientific and technical support staff.

2. Mineralogy and Chemistry Subdivision

2.1 Mineralogy Laboratories

Activities in support of 86 Sector projects and 15 external projects included (with 1986-87 data in parentheses): 877 X-ray identifications (845); 2502 X-ray diffractometer scans (2607); 118 autoradiographs (125); and 4375 hours of electron microprobe, image analysis and scanning electron microscopy (4491). Eighty six percent (86%) of these services were provided to projects in the Branch, and in particular the programs of the ultramafic and gold working groups, the seafloor sulphide study, geochronology and the Mineral Development Agreements.

Significant progress has been achieved in the area of automated analysis and sample characterization using the scanning electron microscope and energy dispersive spectrometer. This provides the capability for unattended operation and the analysis of multiple fields for subsequent analysis and classification, and it is particularly applicable to the characterization of platinum group mineral occurrences.

Field programs in B.C. to document the mineralogy and alteration of epithermal gold deposits in the Mitchell-Sulphurets area and to support the National Mineral Collection were completed as planned. Detailed mapping and sampling of high grade metamorphic assemblages in the Mount Walker area, Somerset Island, N.W.T., first recognized in 1986, were completed. A draft manuscript on the mineralogy of the Hemlo gold deposit for publication as a GSC Bulletin was completed.

2.2 Sample Preparation and Mineral Separation

Numbers of samples prepared for chemical analysis are shown in the following table, together with subtotals for each Division, and showed a 13% increase over 1986-87.

Forwarded from 86-87

MR	LCS	CPG	TS	Other
72	18	0	100	0

Total 190

Received in 87-88

MR	LCS	CPG	TS	Other
4841	492	518	51	132

Total 6034

Completed in 87-88

MR	LCS	CPG	TS	Other
4694	434	410	151	79

Total 5768

Carried forward to 88-89

MR	LCS	CPG	TS	Other
219	76	108	0	53

Total 456

Sample preparation and mineral separation for geochronology included the following: 26 potassium-argon and 78 rubidium-strontium whole rock samples, 118 zircon, 118 monazite, 66 biotite, 49 amphibole and 10 muscovite mineral concentrates. In addition, separations were completed for 390 miscellaneous concentrates for other projects.

2.3 Services to the Public and Collections

Sales of rock and mineral sets continued to show strong demand with total sales of 11,244, a 15% increase from 1986-87. Fifty three percent of the sets were distributed in Quebec. Reports were provided to the public for the identification of 274 samples of minerals and rocks. Revised editions of GSC Papers (66-51) and 70-50) describing Rocks and Minerals for the Collector in the Eastern Townships - Gaspé and the Ottawa - North Bay areas were completed, together with the annual revision of the pamphlet "Information for Collectors". There has been increased activity in all aspects of the curation of GSC collections, including

a 50% increase in shipments to the Reference Collection Facility, Tunney's Pasture, with consequent effects on available resources.

2.4 Chemistry Laboratories

Analytical services continued at the high levels set in 1986-87, in terms of both quality and quantity. Turnaround time has been very good in all laboratories except for hydride determinations by atomic absorption which should improve when the newly acquired spectrometer is put into routine use. Analytical contracts were used to support both A-base and MDA requirements. Details of requisitions, numbers of samples, elements required, distribution of work to various laboratories, date of completion and other pertinent information are maintained in a very extensive laboratory database. Sample throughput increased by 10% over 1986-87, management and contract supervision for MDA samples increased by 17%, and the value of analytical contracts increased by 60% to $300,000.

The status of samples processed is as follows:

	BF	Rec'd	Cmpltd	CF
C&PGD	103	412	377	138
LCSD	271	1448	1406	313
MRD	1199	10999	10200	1998
TSD	27	391	418	0
Other	21	446	394	73
Total	1621	13696	12795	2522
Subtotals				
A-Base	1547	8713	8005	2255
MDA	74	4983	2255	267

BF - Brought forward
CF - Carried forward

Research on method development to improve the capability of the laboratories progressed in a number of areas, including: (a) determination of platinum group elements in rocks to sub-ppb levels using inductively coupled plasma mass spectrometry (ICP-MS); (b) establishment of an efficient method to determine Au, Pt and Pd to 1 ppb in 1-2g samples of ashed vegetation using atomic absorption or ICP-MS with the advantage of low sample weight and freedom from the necessity for fire assay facilities to achieve full recovery of these metals; (c) detection limit for gold in rocks has been lowered to 0.02 ppb, five times below that currently available in industry; (d) a method for the determination of Pt and Pd in waters has been developed and applied to surface waters over deposits at Tulameen, B.C. and Rottenstone, Saskatchwan; (e) removal of Fe and Se interferences in the determination of arsenic by control of reaction kinetics in hydride - AAS; (f) patent applications have resulted from studies in flow injection techniques and a mathematical model derived for optimization of sample geometry in radiation measurements could be advantageous in neutron activation analysis. Atomic absorption instrumentation was evaluated and a new spectrometer was acquired in March that will upgrade our capability for trace element determinations.

Personnel Notes

Dr. Dogan Paktunc was appointed to a term position as a Research Mineralogist in July 1987. This follows a two year period as an NSERC Postdoctorate Fellow during which he completed a comprehensive study of the St. Stephen deposit in New Brunswick. Dr. Paktunc will be responsible for detailed mineralogical studies of several deposits, particularly with respect to their platinum group element potential, as well as contributing to the development of innovative microanalytical techniques.

EXPLORATION GEOCHEMISTRY SUBDIVISION
E.H.W. Hornbrook, Head

The mission of this Subdivision is to provide comprehensive knowledge of geochemical processes, geochemical exploration techniques and statistical methods of data interpretation and integration for use in mineral exploration, planning and assessment of resources, geological mapping and related environmental and public health concerns.

Geochemical Methodology and Research Section

This Section is composed of six research scientists specializing in a variety of methods of geochemical exploration, and two scientists responsible for data management and other support. Current studies include lithogeochemistry, till geochemistry, heavy mineral studies, hydrogeochemistry, biogeochemistry, and the application of computer-based data analysis systems to improve understanding of geochemical surveys. The prime focus of the group is to develop exploration methods that will be of practical application to the mineral exploration industry and other agencies requiring geochemical information. In addition, geochemical data are obtained and compiled to serve as national reference guides of element concentrations in various sample media. Many of the Section's activities are currently directed toward developing exploration methods of value to the search for the full range of precious metals.

Highlights

Developments in studies of groundwater geochemistry include the completion of three bore-hole water sampling systems, of direct value to mineral exploration in areas that have been heavily glaciated. Application has been made to Canadian Patents and Developments Ltd. for patents and licences of these systems. Another study, involving the emplacement of seepage meters, is directed toward determining groundwater flow around lakes.

An exploration problem in glaciated terrains is to determine till stratigraphy and ice movement directions to interpret glacial dispersal patterns, and their relationship to zones of concealed mineralization. The nature and chemistry of the complex overburden stratigraphy within the Abitibi Belt, Ontario, is being investigated by a detailed analysis of cored Quaternary sediments.

Heavy minerals extracted from stream sediments can provide valuable information on the nature and proximity of mineral deposits. Surveys were carried out in Quebec over 8000 sq km of the Lower St. Lawrence region and 3000 sq km in the Eastern Townships. The latter survey followed recommendations by the "Assemble de concertation et de developpement de l'Estrie" to Minister Masse, based on the positive impact of such surveys carried out in the region in previous years.

The greenhouse, on the roof of 601 Booth Street, has been re-established as a laboratory for biogeochemical studies. The distribution of a wide range of chemical elements in common trees and shrubs is being examined to determine which plant tissues are of greatest value for helping to locate concealed mineralization. In Nova Scotia a regional survey has been conducted over a 5000 sq km area. In British Columbia and Saskatchewan detailed studies over zones of precious metal mineralization have demonstrated the effectiveness of biogeochemical methods in outlining gold and platinum deposits. Collaboration with the Mathematical Applications Section, on the integration of biogeochemical data with other geoscience data, has delineated new zones of potential gold mineralization in Saskatchewan. A study of maple sap chemistry has provided baseline data of possible value in determining the cause of the maple die-back problem.

Lithogeochemical studies in the Sulphurets region (British Columbia) have established the extent of a broad precious metal-rich epithermal style of mineralization, in addition to zones of local gold/silver enrichment. The gold content of natural waters from this area has been determined to help define the natural parameters that control gold mobility. In the Atlin area (British Columbia), scanning-electron microscope examination of placer gold grains has helped in identifying their bedrock source.

The Interactive Data Exploration and Analysis System (IDEAS) is a "user-friendly" data analysis system, developed at the Survey, which has undergone further refinement this year, and is supporting geochemical studies in five subdivisions. The system prepares colour graphics and statistical displays to assist in data interpretation.

The monitoring activities associated with a CIDA project in Jamaica have continued, and the final Phase I of report and map are nearing completion.

Personnel Notes

Two permanent staff members have left the Section this year, and have been replaced by term employees. W. Dyck retired at the end of April, 1987; and in February, 1988, N.G. Lund commenced an 18 month period of secondment to the Department of External Affairs. In their places we have the pleasure of welcoming R.M.P. Banville, and Dr. S. Adcock, both of whom will be assisting in data management and support activities to the Section.

Regional Geochemical Studies Section

The objectives of this Section are to carry out geochemical reconnaissance surveys and relate orientation/follow-up studies to: (1) provide a national geochemical data base and (2) to develop and improve the methodology and methods of interpretation and data integration. The regional survey data are used by industry in mineral exploration and to provide a data base for use in resource assessment by government. The data are further applied to aid in geological mapping in thick overburden and to provide relevant information for the investigation of environmental and public health concerns.

Highlights

The Section was involved in Mineral Development Agreements with Newfoundland, New Brunswick, Ontario, Manitoba, Saskatchewan and the Yukon Territory. As part of these programs collection of 12,000 regional geochemical samples covering 167,000 km^2 was undertaken. Joint regional surveys were also carried out in British Columbia under "Joint Letters of Agreement" involving the collection of 2,726 samples over 35,000 km^2. All the 1987 regional geochemical data will be published as Open File releases early in fiscal 1988/89.

In addition to the regional surveys detailed infill drainage surveys were undertaken in three areas: southeastern Labrador, northern Manitoba and northwestern Ontario. These surveys were designed to more fully evaluate the mineral potential of the areas and to supply additional base line information for the interpretation of geochemical data obtained from drainage surveys.

Early in 1987 the results of the 1986 regional geochemical surveys were released as 11 open files consisting of 282 geochemical maps. Based on data obtained from the various mining recording offices, post-release activity in the release areas (up to mid-September) included the staking of 329,000 acres which is up from the 203,000 acres noted last year. Most of the activity focussed on areas of anomalous gold responses and/or associated pathfinder elements such as Sb and As.

Due to continued interest in gold geochemical data, a reanalysis program on 5,000 archived lake sediment samples from Labrador and Saskatchewan was initiated. Analysis is being done by an INAA method, which in addition to gold provides usable data for 20 new elements, including some of the rare earths. Results will be released as four open files in early 1988.

In northwestern Ontario a lake sediment study was initiated to evaluate the use of this surficial medium to PGE exploration. To date detailed sampling has been completed in four areas of northwestern Ontario with known PGE mineralization; Lac des Iles, Jellicoe, Crooked Pine Lake and Marathon. Initial analytical results indicate enhanced concentrations of Pt and Pd as well as other pathfinder elements (notably Cr, Cu, Au, Ni) in all areas which reflect mineralization and/or the host mafic ultramafic complexes.

In northern Manitoba (64B, C) a multi-facetted lake sediment study was initiated. The objective of the work is to provide guidelines for the use of the existing regional lake survey data and delineate exploration targets by: (1) integrating and interpreting the lake survey data with other types of geoscience data via the Spatial Analysis System; (2) undertaking an investigation into the mobilization of gold in the surficial environment.

The preparation and bottling of geochemical international reference samples was completed. A total of 12 samples (4 lake sediments, 4 stream sediment and 4 soil) have been prepared. Considerable analytical data have been received, from 35 participating laboratories, which during the past year was converted to a machine processable form.

Instrumental neutron activation analysis (INAA) has been successfully applied to the analysis of regional drainage sediments. The method provides useful data for approximately 26 elements including gold.

Under contracts 12,100 samples were prepared and 45,000 samples were analysed for a total of 554,000 single element determinations.

Personnel Notes

P.W.B. Friske was appointed to an indeterminate position in the section in July, 1987.

D.J. Ellwood resigned in November, 1987, to accept a position with the Geoscience Information Division.

H.R. Gross accepted a permanent position with the Section as a geochemical data analyst.

D. Wright accepted a term position to undertake data management duties and to pursue GIS studies.

Mathematical Applications in Geology Section

The objectives of the Section are: (1) to develop and apply probabilisitic methods of mineral resource estimation for land-use planning purposes; (2) to develop and apply new methods for the integration and interpretation of various geoscience data sets, including LANDSAT and other remotely sensed data; (3) to develop statistical methods for exploration geochemical and other related geoscience data; and (4) to provide statistical expertise and services to projects throughout the Geological Survey.

These objectives are met by maintaining a long-range research effort on mathematics and statistics with applications to solve current geological problems. Geostatistical techniques and systems of computer programs are prepared for use in projects carried out in collaboration with other Geological Survey staff. Documented computer programs may be transferred to other Sections or to outside organizations. The acquisition of an image analysis facility has greatly enhanced efforts on the interpretation and integration of remotely sensed data with other geoscience data.

Specific topics on which consultation is provided include: (1) fitting of frequency distribution models; (2) trend-surface analysis and geostatistical contouring techniques including "Kriging"; (3) spatial data integration and multivariate statistics applied to geological data; (4) image analysis of remote sensing data, map patterns and photomicrographs; (5) artificial intelligence and expert sytems in geology; (6) statistical analysis of directional features; (7) quantitative stratigraphic correlation techniques; (8) cluster analysis; (9) computer simultation of geological processes; (10) geostatistical crustal abundance models; (11) truncated or censored data analysis; (12) stochastic process modelling of flow in heterogeneous porous media.

Highlights

The SPANS Spatial Analysis System and EASIPACE Image Analysis System were installed on microcomputers. Initial demonstration projects using these two systems were performed for spatial data integration in the Star Lake area, Saskatchewan, in northern New Brunswick and in eastern Nova Scotia. The systems are already showing great potential for a variety of applications.

New statistical techniques and the corresponding computer programs have been developed for the analysis of truncated and randomly censored data such as geochemical determinations with detection limits. Multivariate statistical techniques of truncated and censored data are being tested.

A joint project with VIOR/MAZARIN in northern Quebec was initiated to investigate use of LANDSAT imagery to detect alteration zones associated with gold mineralization.

Adaptation of artificial intelligence methodology for applications in geology has resulted in a new method for combining various types of geoscience data in mineral exploration. The method consists of adding weights of evidence to different features which are related to mineralization. This results in increased probabilities for the detection of undiscovered mineral deposits.

In collaboration with the Borehole Geophysics Section, a statistical approach was developed to resolve the stripping problem in spectral gamma ray borehole logging.

In conjunction with the Ottawa – Carleton Centre for Geoscience Studies, three theses were completed by graduate students working in association with members of the Section and other GSC staff; (1) geostatistical modelling of microfossil abundance data in Upper Jurassic shale, Tojeira Sections, Central Portugal (K. Nazli, MSc thesis, December, 1987); (2) Multivariate and spatial statistical analysis of lithogeochemical data from metavolcanic rocks in the Ben Nevis area, northern Ontario (E.C. Grunsky, PhD thesis, March, 1988); and (3) Quantitative biostratigraphic analysis of the Cenozoic of the Labrador Shelf and Grand Banks (M.A D'Iorio, PhD thesis, March, 1988).

Personnel Notes

Alexandre Desbarats joined the Section as a Research Scientist in July, 1987 to work on stochastic modelling and geostatistical analysis of geoscience data.

Hubert George arrived in June, 1987 to commence an NSERC fellowship for spatial data integration and image analysis in geology.

Yuan Ding left in August, 1987 to become a PhD student at Syracuse University after a one-year stay in the Section as a visiting Chinese research scholar.

Special Projects

The study of Archean gold mineralization is the main responsibility of the senior staff geochemist in Special Projects.

Study of a large ductile shear zone in southern Norway has shown a pronounced depletion of gold and associated elements in these ower crustal rocks that are equivalent to the deep crust underlying major gold districts of the Abitibi belt. These studies suggest removal and transport of gold by an oxidized stream of carbon dioxide fluid that originated inthe mantle.

GEOPHYSICS AND TERRAIN SCIENCES BRANCH

J.S. Scott

GEOPHYSICS DIVISION

M.J. Berry

General

The Division was formed on April 1, 1986 from the national surveys and observatories components of the former Earth Physics Branch, and the aeromagnetic surveys program of the former Resource Geophysics and Geochemistry Division. The new Division's role is to conduct programs that will provide data and expertise concerning geophysical realms and processes on a continent-wide scale, from which a better understanding of the Earth's near-surface and deeper structure, dynamics and potential hazards can be obtained.

In 1987-88 the Division's activities were reorganized under two subdivisions. The Seismology and Geomagnetism Subdivision remained as before, comprising the Seismology, Geomagnetism and Geophysical Instrumentation Sections. The Aeromagnetics, Gravity and Geodynamics Subdivision now amalgamates activities in these three programs. The Division's operations are supported by an Administration Section. The program of the Division was conducted by its A-Base staff of 116, supported by two positions assigned to Frontier Geoscience Program activities, and two positions under the Manitoba and New Brunswick federal-provincial MDA Programs. The research program was complemented by four NSERC post-doctoral fellows. The Division's facilities are concentrated on the Observatory Campus of the Central Experimental Farm and at the Anderson Road Laboratory on the eastern edge of Ottawa. Smaller groups operated from the Alert Hangar and the National Aeronautics Establishment at Uplands. Seven personnel were stationed at the geophysical observatories at Priddis near Calgary, at Yellowknife and at Mould Bay and Alert in the Arctic Islands.
The Division is the national archive and data centre for seismicity and geomagnetic studies, and gravity and aeromagnetic surveys. In addition it provides instrumentation and computer facilities in support of seismic and electromagnetic field surveys of the Lithospheric Geophysics Section of the Lithosphere and Canadian Shield Division, and supports the seismographic networks based at the Pacific Geoscience Centre.

Highlights

Construction and testing was completed of the new, three-component digital seismograph network that has taken two years in design and preparation, and the six-station array was installed and calibrated at Charlevoix, Quebec, in October. The system, which enhances capabilities for earthquake detection in this seismically active zone of eastern Canada, has now operated for 5 months at greater than 95% effectiveness, with excellent data transmission to the Ottawa data laboratory.

The existence of high-angle splay faults, formed during the December, 1985 magnitude 6.9 main-shock rupture in the Nahanni region, has been identified from analysis of the 1986 aftershock field survey data. The splay faults seem to represent the failure of a major barrier in the hanging wall above the main seismic rupture which produced the additional moment release, increased complexity and focused the strong ground motion observed for the main shock. A magnitude 6.2 aftershock occurred in the Nahanni zone on March 25, and analysis has commenced of data from the subsequent field survey and records retrieved from two strong motion accelerographs that had continued to operate in the region since the 1985 earthquake.

The new Canadian Geomagnetic Reference Field for epoch 1987.5 was compiled from observatory data and data obtained during the 4-year, cyclical reoccupation of magnetic repeat stations (14 in 1987-88). The Reference Field is recompiled at roughly 2-4 year intervals as new data are available, and is the basis for all navigation and surveying by magnetic compass in Canada; all topographic and aeronautical charts for Canada contain information derived from the Reference Field.

Analysis of the mathematical modelling of geophysical fields by Fourier series and rectangular harmonic analysis techniques has demonstrated serious deficiencies in these widely used approaches due to the use of incorrect mathematics. The analysis points out the preferred use of spherical cap harmonic analysis over large areas, refined in the Geophysics Division for modelling the geomagnetic field, and for which computer programs were completed and published during the year.

A high-resolution, total field aeromagnetic survey covering all of Lake Superior was completed using the Queenair aircraft. The survey, jointly funded by the GSC and USGS, covered 59,916 line kilometres at a line spacing of 1.5' longitude and completes mapping of the Great Lakes. The survey incorporated several technological advances, including a data acquisition system developed in-house based on a TI9900 microprocessor, the first use of a Bernoulli disc rather than magnetic tape to record data, and a trailer-housed field checking system reeported in a GSC Open File release. Approximately 50% of the survey data have been compiled. The completed project will result in over 100, 1:50,000 maps. This survey, the largest carried out by the Queenair, will be the final survey of this type within the GSC as plans are underway to transfer the aircraft and its unique survey capabilities to industry in keeping with the Department's policy of contracting facets of its programs to outside agencies.

The fifth edition of the colour Magnetic Anomaly Map of Canada was published at a scale of 1:5 million, making it the first edition that was compiled entirely from digital data. The Magnetic Anomaly Map of North America, also at 1:5 million, was published in collaboration with the USGS. The GSC responsibility in this project was data compilation and reduction.

Following four years of collaborative effort between the GSC and the USGS, the first gravity anomaly map of North America was published at a scale of 1:5 million. The map was produced for the Decade of North American Geology (DNAG) series under the direction of the Committee for the Gravity Anomaly Map of North America, chaired by

J.G. Tanner, former Chief Geophysicist of the GSC. Preparation of colour separates, drafting and printing were the responsibility of the Gravity Data Centre, Geophysics Division. The 1,869,000 spot values covering Canada, Greenland, U.S.A., Mexico, Central America the Caribbean and adjacent oceanic regions were compiled by the USGS under guidance of the Gravity Data Centre.

The development of the Canadian Geophysical Long Baseline Interferometry (CGBLI) system continued with six observing sessions on the Algonquin-Penticton (ARO-DRAO) baseline. The Data Acquisition and Recording Terminal (DART) and the Correlator and Data Processor (CODAP) systems developed under contract have been debugged, and the first fringes detected to prove the concept of this advanced system. The Division continued to provide real-time positioning and navigational data for the Canada Ice Island projects through the use of two advanced geodetic satellite receivers for continuous tracking of the Navy Navigational Satellite System.

The Division sponsors, through a committee of scientists representing the several GSC divisions on Observatory Campus, a roughly bi-weekly series of seminars covering a broad range of geophysics disciplines. The seminars present current activities of GSC scientists and those of renowned researchers visiting from other Canadian institutions and from other countries. In 1987-88 twelve of the twenty-eight presentations were by GSC scientists from four divisions, while the remainder included speakers from the USA, West Germany, China, the Netherlands, and six Canadian universities.

The seventh annual Geological Survey of Canada Current Activities Forum was hosted by the Geophysics Division on behalf of the GSC, January 19-20, 1988. The evening public lecture preceding the Forum technical sessions was presented by P.W. Basham of the Division who offered an overview of earthquakes in Canada and the GSC's role and responsibilities in their monitoring and understanding.

The Geophysics Division played a prominent role in organization and activities of the XIX General Assembly, International Union of Geodesy and Geophysics (IUGG) held in Vancouver, Aug. 9-22. Fifteen scientists presented 4 invited and 13 contributed papers at special symposia and technical sessions. Several Division members hold executive positions on various IUGG Associations and Committees, and they played an active role in business meetings held in conjunction with IUGG. National geophysical programs of the GSC was the theme of a display prepared for the Assembly by the Division, and featured maps of Canadian seismicity, earthquake hazards, magnetic and gravity anomalies, magnetic declination and radiometric surveys.

Division scientists presented three-day workshops at each of Montevideo, Lima and San José, Costa Rica, on the newly developed GSC gravity data reduction system for microcomputer. Copies of the software were provided to the Latin American participants as part of the GSC's participation in the work of the Pan American Institute of Geography and History (PAIGH).

Administration Section

This section, comprising the Director, Assistant, Secretary, Administrative Officer, clerical and procurement staff, draftspersons and photographer, provides general administrative support and financial and personnel management for the Division, and support where required, particularly drafting and photography, for staff of other GSC divisions resident on the Observatory Campus.

Personnel Notes:-

Madeleine (Mem) Levesque, at one time Geomagnetism secretary and Head, Records Management and General Office Services, Earth Physics Branch, rejoined the geophysics activity as Administrative Officer, Geophysics Division.

Len Collett, who formally retired from the Mineral Resources Division, joined the Geophysics Division on a part-time basis to provide advice and experience in relations between government and the geophysics exploration industry concerning instrumentation research and development and technology transfer.

Lorne Campbell transferred from DIAND to the Drafting and Design Section of the Geophysics Division

Lyman Warren retired after a 37-year career in the Public Service, of which the last 6 years were spent as Head, Drafting and Design Section of the Earth Physics Branch/Geophysics Division.

The Drafting and Design Section also lost Suzanne Cumyn who retired after 13 years with the Earth Physics Branch/Geophysics Division.

SEISMOLOGY AND GEOMAGNETISM SUBDIVISION

P.W. Basham

Seismology Program (R. North)

The Canadian Seismic Network of 13 standard and 49 regional stations was operated successfully, mostly through contracts, and with an average 'up time' of nearly 98%, to provide fundamental data in the determination of Canadian seismicity and research in seismotectonics. The Port Hardy, B.C. and Montreal standard stations were downgraded to regionals as a cost-saving measure. A prototype, state-of-the-art, digital regional station was designed, constructed and tested in Ottawa and PGC. This type of instrument will replace the current analog record type instrumentation in the future, allowing scientists to receive data by telephone or satellite and to perform real-time analyses.

The Eastern Canada Telemetry Network (ECTN), that provides high quality digital seismic data for locating earthquakes in eastern Canada, operated with an average 'up time' of greater than 95% - a slight improvement attributable in part to installation of radomed antennae on the radio-telemetry portion of the network. The telemetred seismograph network in eastern Canada was significantly expanded with the installation of two local autonomous networks in Charlevoix, Quebec (see Division Highlights) and Sudbury. The Sudbury Local Telemetry Network (SLTN) centred on Science

North, operated smoothly providing digital data telemetred to Ottawa in a study to improve understanding of rockbursts in underground mines. The project is funded and is part of a joint Federal-Ontario Government and mining industry initiative to address the rockburst hazard in the northern Ontario mining district. Since September, 93 rockbursts have been documented, including many that would otherwise have gone undetected.

A total of 1468 earthquakes in or near Canada, 35 of them felt, were documented in the year. Information on these events is immediately available from the seismicity database and from the regular seismicity reports issued nine months in arrears. Distribution of Canadian seismic data to U.S. and Sweden daily, U.K. weekly and U.S.S.R. monthly was carried out in support of Canada's role in the global seismicity network in earthquake and nuclear explosion monitoring. A monthly bulletin was prepared for External Affairs, listing and identifying earthquakes and nuclear explosions throughout the world. Quarterly reports were issued to the U.S. Nuclear Regulatory Commission from ECTN data, and to Hydro-Québec and Ontario Hydro from seismic monitoring in the neighbourhood of recently loaded reservoirs and nuclear power plants.

A comprehensive analysis of data collected on earthquakes in northern Ontario since 1983 and the tectonic implications for underground nuclear fuel waste repositories has been prepared for AECL. The low seismicity character of the region has been essentially substantiated, although the more than thirty tremors recorded in this period is somewhat more activity than was anticipated on the basis of the recordings from the more sparse national network. A higher level of activity exists east of 85° longitude in comparison with the western and northwestern parts of the province.

The continued increase in digital seismic data - 2583 digital earthquake files were archived in 1987- requires upgrading and refinement of hardware and software for data archiving, retrieval and processing in the seismology data lab. The recent connection of the new LCSD CONVEX C1-XP minisupercomputer to the network will help improve the situation. Modifications to the CDTSN code that now runs in seven earthquake monitoring systems in Canada, and will be used as the basis for the CIDA-sponsored Seismic and Volcano monitoring project in Colombia, have been completed. The code was transferred to Industry under the IRAP program during the year. Enhancements developed for the SAM analysis package that now runs in Ottawa, PGC and Science North have aided rapid analysis of Canadian earthquakes.

Of possible consequence to the east coast offshore exploration industry was the recording of five Laurentian Slope events, three others on the Scotian Shelf and eight in the Grand Banks/Labrador Sea region. In the OERD-supported east coast seismicity project, ninety-eight Labrador Sea earthquakes from 1934 to 1987 were relocated, some by as much as 100 km, through improved analysis techniques. In general, the epicentres now conform more closely to the Labrador Sea spreading axis. These analyses also reveal that the northern extremity of the axis is offset slightly westward along the Hudson Fracture zone transform fault, and that the axis can be extended another 100-150 km northward on the basis of seismicity. There is also a suggestion that earthquakes in southern Labrador and eastern Quebec may be connected with a late Precambrian-early Cambrian transcurrent fault system that extends south-southwest from Lake Melville to join the Iapetus rift faults under the St. Lawrence River. The compilation of historical seismicity of the Atlantic region being carried out under contract through examination of archival materials, some dating back to the seventeenth century, is 80% completed, and the interpretation phase has commenced. Although the number of known earthquakes in Nova Scotia, for example, has doubled as a result of this study, the newly recognized events are small and no major changes are expected in the picture of the regional seismicity.

Research into the physics of earthquake sources has been carried out on a number of fronts. Mechanism analysis was carried out on eleven of the larger events of the past year in eastern Canada. The various modes of mine-induced tremors in potash, coal and metalliferous mines in Canada have been described and analytic expressions for their characteristic seismic radiation patterns have been derived. Analysis of the basic aspects of neotectonic movements in Canada has been completed, and indicates that in the Hudson Bay and St. Lawrence valley regions vertical movement is almost exclusively a result of post-glacial rebound.

Seismic data from the 1929 Grand Banks earthquake has been interpreted to favour a slump, rather than a fault mechanism. The volume of slumped material calculated from these data is in remarkable agreement with in situ measurements. Evidence from the offshore Cascadia turbidites over the last 5000 years supports the historical occurrence of great earthquakes in the Pacific Northwest at approximately 450-year return periods. Summaries of seismicity, crustal stresses and seismotectonics of eastern Canada have been published.

Research on earthquake magnitudes through analysis of propagation and attenuation of seismic waves has indicated that the postulated sharp discontinuous increases in shear-wave velocity with depth in the lower mantle is not a unique interpretation of observational data, and that wave scattering by 3-dimensional structural irregularities is a possible alternative.

In this, the second of the three-year project to modernize completely the Yellowknife seismological array with special funds approved by Treasury Board, most of the acquisition and construction phase was completed. Developments included: construction of a new operations centre building where data will be received by radio telemetry from the individual instruments of the array, archived and transmitted via satellite link to the Ottawa data laboratory; completion of new vaults for the digital, broad-band seismometers; completion of the Yellowknife project design document including software design; and acquisition of almost all of the required computer hardware. During renovations the existing array continued to function effectively in gathering data on underground nuclear tests and earthquakes around the world.

Analysis of data from the Yellowknife array and from the digital seismograph networks in eastern Canada has been used to improve understanding of the seismic character of underground nuclear explosions, particularly in shield terrains, in order to refine our capabilities of detecting and discriminating these events from earthquakes. Five previously unannounced nuclear tests by France in the South Pacific were recognized, and subsequently confirmed by sources in New Zealand. Advances were made in developing techniques to characterize rapidly and estimate the explosive yield of Soviet and U.S. nuclear explosions. Canada is represented on the Disarmament Group of Scientific Experts by Division scientists who have been chosen to coordinate a large scale experiment on international seismic data exchange.

Personnel Notes:-

Jim Helferty joined the Seismology Section as an electronics technician in the seismological data laboratory.

Dennis Monsees, Officer-in-Charge of the geophysical observatory at Yellowknife since 1974, received a Merit Award for his outstanding contribution to the seismology program through his abilities to keep all systems operating at the laboratory under all conditions.

Dr. Anne Stevens was seconded to the Director-General's office as Scientific Executive Assistant.

Geomagnetism Program (R.L. Coles)

The 13 stations of the Canadian geomagnetic network were operated at greater than 98% efficiency to provide data on the geomagnetic field over the polar, auroral and sub-auroral regions. In-house development progressed on instrumentation, hardware and software for a prototype of the new Canadian Magnetic Observatory (CANMOS). The CANMOS observatories will incorporate the new scientific and operational specifications established from a comprehensive, in-house review. The new stations will enable Division staff to have access to the station data on a daily basis, thus providing them with the data they require to improve their forecasts of the geomagnetic field.

The year's digital data from the 13 observatories (1 minute sampling intervals) were processed and made available to government, industry and universities according to established formats and schedules. Requests (over 500) were filled for declination and related information based on the Reference Field. These data, together with microfilm copies of analog plots were deposited in World Data Center A (Boulder) as Canada's contribution to the World Observatory Network. Transfer of processing operations from a CDC Cyber-based system to a MicroVAX and PC system was completed, and is expected to provide greater efficiency.

The Section issues routine forecasts of geomagnetic activity and special 'alert' messages of major activity, based on daily analysis of observatory data. Knowledge of increased magnetic activity is of particular importance to the continuous and smooth operation of electric power utilities in particular. The earth is entering the upswing phase of the 11-year solar cycle of geomagnetic activity, with the result that ten 'alerts' were issued during the year. The three-week forecasts were provided to 230 subscribers in government, exploration, telecommunications and power utility agencies. In addition, over 1300 calls were received for the daily recorded 72-hour forecasts that have been evaluated at 75% accuracy for the immediate 24-hour period. Research on linkages between solar and geomagnetic activity has led to greater confidence in forecasting the very quiet conditions ideal for certain surveys and experiments. In addition, a capability has been achieved to forecast irregular, short-term pulsations that are not part of the long-term forecasts, and that interfere with some types of surveys. Advances have been made for correcting data to remove variations in the magnetic field, towards the goal of being able to carry out surveys under non-ideal conditions, for example, eliminating the need and expense of waiting for a 'quiet' period when recalibrating magnetic repeat stations in remote localities.

At the request of the Geographical Services Directorate, S&M, inverse equations were developed that permit conversion of coordinates on the modified polyconic map projection used above 80°N on many GSC and S&M maps. These conversion formulae are necessary for the proper registration of data in data bases for the high Arctic areas.

Personnel Notes:-

Benoit St. Louis joined the Instrumentation Section at the Anderson Road Laboratory to provide electrical engineering skills in development of the Canadian Automated Network of Magnetic Observatory Stations (CANMOS).

AEROMAGNETICS, GRAVITY AND GEODYNAMICS SUBDIVISION

R.A. Gibb

Aeromagnetics Program (R.A. Gibb)

The former Aeromagnetics Subdivision underwent changes in terms of its organization, program and location. Aeromagnetics now forms part of the Aeromagnetics, Gravity and Geodynamics Subdivision to more closely reflect the relationship of various potential field studies in this subdivision.

The research and data management aspects moved to the Observatory Campus where closer ties with equivalent operations in the Gravity Program can be developed. The Contract Surveys section has been temporarily relocated at the Alert Hangar following the loss of the City Centre facilities. With the suspension of in-house research and development of aeromagnetic survey, navigation and data acquisition projects, and field testing and surveying using the GSC's Queenair aircraft, technical staff have been reassigned within the Division where their expertise can be employed in related studies in the other geophysical survey operations. To continue the excellent tradition and reputation of Canadian research and development in aeromagnetic surveying instrumentation, the

Division has established an Advisory Committee. The committee, comprising representatives from government and the manufacturing, geophysical contracting and geophysical consulting facets of industry will foster and financially support proposals for development of instrumentation and software for data acquisition, representation and interpretation.

A number of aeromagnetic total field surveys were carried out in support of research objectives of the Sector, while several aeromagnetic gradiometer/VLF EM surveys were continued or commenced according to interests pursued under the Federal-Provincial Mineral Development Agreements (MDA's). All surveys, other than the Queenair survey of Lake Superior (see Division Highlights), have been carried out under contract, by six different Canadian survey firms.

The several MDA's are nearing conclusion and progress in 1987-88 is summarized as follows: Eighteen total field and 18 vertical gradient maps were published for the Grand Falls-Tuadook Lake area, N.B. Compilation of data from 1986-87 surveys in the Cobequid Mountains, N.B., the Springdale-Bishops Falls area, Nfld. and Rice Lake, Hargrave River and Moose Lake regions, Manitoba, was completed. Data acquisition and compilation was completed for 1987 Surveys in the Saint John area, N.B., Kenora-Ft. Frances and Beardmore-Geraldton areas of Ontario. Data acquisition was completed for total field surveys in the Prince George area, B.C.

The total field survey of 34,200 line km over the Grand Banks was completed in support of FGP activities at the Atlantic Geoscience Centre. The aeromagnetic survey of the Williams Lake region, B.C., to investigate the connection between magnetic disturbance of the Shield and structure west of the RMT LITHOPROBE transect, was completed whereas the extension into the Lethbridge region, Alberta, was delayed to 1988.

Division staff worked with the National Aeronautical Establishment of NRC to establish tielines across the Arctic Islands as control for the magnetic anomaly map of North America, as well as shorter lines across Arctic channels for defence purposes. The reconnaissance survey and data processing of southern Greenland has been completed for the Greenland Geological Survey who are preparing the contoured map. A number of navigation systems were tested and compared during these flights and in the laboratory.

Compilation of digital data from high resolution aeromagnetic surveys flown by the Queenair in the two previous seasons has been completed; a total of 81 sheets were compiled at 1:50,000 scale for Lake Huron, Waterloo, Lake St. Clair and Camp Borden areas, and eight 1:250,000 contoured maps prepared from the Lake Huron survey. In addition, 33 aeromagnetic maps were published in the Lake Ontario, Lake of the Woods and Alberni, B.C. regions. Six aeromagnetic maps in the 1:1 million NESS series were published, bringing the total published to 51.

Personnel Notes:-

Reorganization of the aeromagnetic program and accommodation constraints occasioned a number of moves during the year. The data processing group under Dr. Dennis Teskey moved from 601 Booth Street to Observatory Campus. The contract surveys group under Ed Ready moved from City Centre to the Alert Hangar at Uplands Airport. With suspension of operation of the Queenair aircraft for in-house surveying, the skills in geophysical instrumentation development in the aeromagnetic survey group have been relocated within the Division. Dwayne Olson, Howard Knapp and Aurel Dicaire joined the Instrumentation Section at the Anderson Road Laboratory, while Dick Flint's expertise in aeronautics is contributing to the development of the airborne gravity project.

Dr. Peter Hood transferred to the Mineral Resources Division. Wim Knappers was seconded to CIDA for approximately two years to oversee geophysical survey projects being carried out by Canadian industry for the Government of Thailand.

Gravity Program (R.A. Gibb)

Regional mapping in the National Gravity Mapping Program of Canada has continued to be focused in the Arctic islands, channels and offshore regions. A regional gravity survey from the ice, comprising nearly 2000 stations at 6-20 km spacing over the polar continental shelf west and north of Axel Heiberg Island, was carried out in cooperation with the Canadian Hydrographic Service and PCSP, and completed gravity coverage of the entire shelf from the Mackenzie Delta to Ellesmere Island. A regional survey combining more than 700 marine and land gravity stations was conducted over Axel Heiberg and parts of Ellesmere Island for Sverdrup Basin studies of the Frontier Geoscience Program at ISPG. This was the first operational use of the Inertial Survey System for vertical positioning north of 80°N. Data from both surveys are available in the National Gravity Data Base. In addition, the data base for eastern Canada has been expanded by inclusion of gravity data from an underwater survey of Trinity and Bonavista Bays, Newfoundland, performed in cooperation with Memorial University and five land gravity projects carried out by that university. Also added were 230 new gravity values observed in southwestern British Columbia by the Department of National Defence.

Two localized gravity surveys, southeastern B.C. and the northeast margin of Lake Huron, were carried out in support of geological mapping and interpretation by LCSD scientists, and data reduced and edited for the National Gravity Data Base.

The National Gravity Data Base provides data storage, retrieval, display and special map product services for gravity and crustal motion data, and is available for access in support of government research programs, the petroleum and mineral exploration industries, universities and the general public. In 1987-88 the data centre responded to 339 GSC requests and 220 external requests, which included digital data, line-contoured or coloured Applicon maps (400

produced to specifications) for localized geological features, geological provinces and the entire country, plus copies of software developed in-house for reduction, editing and processing potential field data. The data centre also produces gravity anomaly maps in the 1:1 million NESS series; thirty maps have been compiled and will be produced in the coming year. The Sudbury Sheet will be the first.

Research has continued on developing and improving computer methods, techniques and systems required for the reduction, editing and analysis of gravity and related data. In particular, a terrain correction program has been compiled that utilizes digital topographical data files supplied by Surveys and Mapping, and which has the potential to alleviate one of the most tedious aspects of gravity reduction. Derivative gravity products, including isostatic, enhanced isostatic, gradient and shaded gradient maps, were produced to aid in geological and structural interpretation of various areas.

Considerable progress was made in the computation of a gravimetric geoid for Canada through development of programs to calculate the geoid and gravity from satellite models, to verify the geoid computation procedure and to amalgamate various data sets to be used in geoid computation and reduce them to a common reference surface.

In-house research, development, laboratory and field testing of the absolute gravity meter has been largely completed, and a number of application surveys have commenced. The meter was transported via the GSC Skyvan to Calgary, Resolute, Yellowknife, Churchill and Inuvik, and via military aircraft to Alert. Measurements at each site were used to readjust the 5000 stations of the Canadian Gravity Standardization net and to provide an absolute reference system for all gravity surveys in Canada. Secular changes in gravity of the order of 10 to 15 microgals observed in only one year with the absolute meter in the local Ottawa crustal-stability network may be related to movements across large-scale faults in the Ottawa Valley Graben.

In the Geophysics Division, research and interpretation employing gravity data focuses on the use of large-scale and digital data bases to address general problems in crustal genesis. Derivation of the horizontal gravity gradient map of North America, a technique that removes long wavelength features, improves recognition of shield features under the cratonic Phanerozoic cover. The southern and western boundaries of the Superior Province have been defined west of the mid-continent ridge; the boundary between the Wyoming Province and the Trans-Hudson Orogen is seen to extend northward into the Churchill Province; southwesterly extension of the Grenville Front is enhanced, and has been repositioned approximately 100 km east of previous suggestions. Analysis of gravity trends reflecting structural patterns in the major structural domains of North America, among other findings supports the suggestion that continental collision did not play a major role in accretion of the continent in the south-central United States.

Impact cratering is likely the only geological process common to the surface of all planets and moons in the inner solar system, and an understanding of the impact process and subsequent morphologic modifications provides a key to the nature, age and evolution of these bodies, including the earth. A comprehensive petrographic study of deformation in the Vredefort structure, South Africa was completed which supports an impact origin for the largest and oldest such structure recognized on the earth. At the request of IUGS and NASA, respectively, a world map and an astronauts training guide on terrestrial craters were prepared, drawing on the comprehensive cratering database compiled in the Division.

The Division's role in the Lomonosov Ridge Exploration (LOREX) and the Canadian Expedition to Study the Alpha Ridge (CESAR 83) has been completed. Twenty-six multidisciplinary papers on the LOREX project from a number of scientific institutes have been compiled in a volume to be published by the GSC. A comprehensive review of all major Arctic Ocean field research, including LOREX and CESAR results, is in press. Gravity and bathymetry determinations have been extended from the Queen Elizabeth continental break to complete a continuous transect from the North Pole to Ellef Ringnes Island.

Personnel Notes:-

Dr. Mark Pilkington, who recently earned his Ph.D. at McGill University, joined the Applications Group in the Gravity Section as a postdoctoral fellow to address problems in large-scale crustal structure in N. America using potential field data and analysis.

Geodynamics Program (J. Popelar)

Development of the Canadian TRANET II satellite tracking stations at the Ottawa and Calgary observatories was completed by implementing a dual receiver refraction channel operation. This resulted in significant improvement in production and quality of Doppler data essential for computation of precise geodetic satellite ephemeris over Canada, and satellite polar motion monitoring. Fine weather conditions contributed to above average production of the Photographic Zenith Tube (PZT) data which have been transmitted weekly to the international services (BIH, IPMS and IERS) for evaluation of global earth orientation parameters. Direct minicomputer control of nightly PZT operations was implemented at the Ottawa and Calgary observatories.

The transfer of the TRANET operations to the Algonquin Radiotelescope site (ARO) has been investigated in several site monitoring studies that indicate the suitability of this location, provided a data communication link to the Ottawa laboratory can be established. An agreement is under discussion that would have the ARO site jointly operated and maintained by the Geophysics Division, the Geodetic Survey, and the Herzberg Institute, NRC.

Advances were made in mathematical methodology and applications for satellite global positioning and navigation. Global Positioning System (GPS) data processing and reduction software has been improved

to facilitate relative GPS positioning below 0.5 ppm (new preprocessor and tropospheric refraction modelling) as demonstrated by comparison of GPS and state-of-the-art ground-based laser distance measurements in the Port Alberni area, B.C. (agreement to within 1 cm over 20 km). A new method to facilitate more economical data processing of large volumes of satellite-to-satellite observations has been developed in preparation for geopotential satellite research missions.

Global dynamics monitoring and research was carried out on a number of fronts. Results from twelve years of intensive monitoring of tilt, strain, well levels and gravity variations in the Charlevoix seismic region have been compiled. While no clear correlation could be demonstrated between the parameters monitored and specific earthquakes during 1974 to 1986, coincident changes in seismic travel-times, gravity and electrical impedance observed over part of this period are consistent with fluid flow in the crust parallel to the St. Lawrence River two years before a magnitude 5 earthquake. Reflecting the change in emphasis of strain measurement, the first comprehensive crustal motion survey in this zone was carried out jointly with Geodetic Survey and comprised over 200 km of special-order levelling, 30 special-order line lengths and 35 precise gravity ties. Although repeated horizontal control surveys carried out in the broad region since the 1920's have shown no significant changes, it is hoped that improved techniques providing greater accuracy may detect evidence of strain accumulation and release when the comprehensive survey is repeated at four-year intervals.

Field tests were carried out with the new absolute gravity meter that demonstrated a precision of better than 2 microgals. At this level of precision the expected post glacial rebound signal of 2-4 microgals/yr (2-3mm) around Hudson Bay should be measurable in a few years of monitoring. On the theoretical side, modelling of glacio-isostatic adjustments in shield areas has been extended to compressible materials which show a lesser initial response than rigid material, completing the study on loading of multi-layered, viscoelastic, compressible earth necessary for both stress and displacement calculations.

The Canadian Superconducting Gravimeter Project, which will be used to search for undertones in the earth's core and to develop models for gravity tides and atmospheric effects, received NSERC approval. In preparation for acquisition of the first instrument, noise level studies were carried out at existing federal government sites.

Personnel Notes:-

Jacques Labrecque retired after a 38-year scientific career in the Public Service that included 32 years in the Observatories Branch/Earth Physics Branch/Geophysics Division.

Dr. Don Bower retired after 41 years service in the Public Service, the latter 30 spent in the gravity and geodynamics programs of the Dominion Observatory/Observatories Branch/Earth Physics Branch/Geophysics Division, GSC. Don's expertise in measurement of dynamic earth processes through earth-tide and tilt monitoring has not been lost to the Section as he will continue his research on a one-third time basis for another year.

Dr. Yola Georgiadou and Dr. Detlef Wolf completed two-year post-doctoral fellowship terms.

Dr. Bill Petrachenko, who had been a post-doctoral fellow in the Section in 1982-84, rejoined the Global Dynamics Group in the CGLBI project.

TERRAIN SCIENCES DIVISION

D.A. St-Onge, Director

INTRODUCTION

The primary responsibilities of the Division are to ensure the availability of comprehensive knowledge, technology and expertise on the surficial and Quaternary geology, glaciology, geomorphic processes and natural terrain hazards of the Canadian landmass and on the practical applications of terrain science.

Divisional objectives arising from these responsibilities are: to provide a systematic coverage of modern standard surficial geology maps throughout Canada, provide information on paleoecological, paleoenvironmental and glaciological conditions as a means for establishing rates and directions of climatic and environmental change, document geological and geomorphological conditions and natural terrain hazards that influence environmental and resource development issues, develop and evaluate geophysical methods and techniques for delineation of bedrock, surficial geological and permafrost conditions affecting land use, develop sedimentological and geochemical methods for mineral prospecting in drift-covered regions and for evaluation of the impact upon terrain and the environment of phenomena such as acid rain. The Division also provides standards, controls and reference materials to ensure consistency of correlation between geological events of the Pleistocene and Holocene Epochs and to develop and maintain standards of mapping of surficial geology appropriate to national needs.

The Divisional organization comprises three Subdivisions: Quaternary Geology, Quaternary Environments, and Terrain Dynamics. Quaternary Geology Subdivision has responsibility for systematic Quaternary geological mapping of the Canadian landmass exclusive of offshore areas, development of mineral exploration methodology based upon characteristics of glacial sediments and operation of the radiocarbon laboratory. Quaternary Environments Subdivision is responsible for paleontological and paleoecological investigations of Quaternary fossil materials as an aid to stratigraphic correlation and determination of paleoenvironments, studies of arctic glaciers also as an aid to paleoenvironmental and paleoclimatic interpretations, and operation of Divisional sedimentology laboratories. Responsibilities for studies of active geomorphic processs, including landslides, permafrost, erosion and related terrain hazards and development of geophysical methods, particularly shallow seismic reflection and refraction techniques and ground profiling radar systems are centered within Terrain Dynamics Subdivision. Scientific activities of the Subdivisions are complemented by a Sedimentology Research Unit which maintains and develops expertise and techniques in Quaternary sedimentology and geochemistry pertinent to terrain and related environmental problems.

During the year the scientific program of the Division continued to be strongly influenced by involvement in federal/provincial mineral development agreements in Labrador, Nova Scotia, New Brunswick, Ontario and Manitoba, federal programs to encourage mineral exploration in Gaspé and Eastern Townships of Quebec, northern research funded through the Office of Energy Research and Development and through participation in geophysical investigations from the Ice Island off the northwest coast of Ellesmere Island supported by the Frontier Geoscience Program. These special programs provided an aggregate of 73 per cent of the total O&M funding allocated to the Division.

Further administrative restructuring will result in the elimination of the Sedimentology Research Unit and a complete reorganization of the Quaternary Geology Subdivision.

A new Division Director was appointed on October 1, 1987. The former Director became Director General of the Geophysics and Terrain Sciences Branch. During the year 3 Research Scientists retired and one long-term Physical Scientist died while working in the Ottawa area.

QUATERNARY DISCUSSION GROUP

Under the Chairmanship of R.J. Mott the following papers were presented during April 1987 to March 1988.

Dr. J-S. Vincent, Terrain Sciences Division, GSC, Ottawa – The Quaternary of the Northern Interior Plains and Western Canadian Arctic Archipelago.

Dr. M. Lamothe, Terrain Sciences Division, GSC, Ottawa – A new concept for the Pleistocene stratigraphy of the St. Lawrence Lowland.

Dr. A. Latham, Lithosphere and Canadian Shield Division, GSC, Ottawa – Uranium series dating of Quaternary materials: potential and problems.

Dr. H. Josenhans, Atlantic Geoscience Centre, GSC, Dartmouth – The Quaternary sediments of Hudson Bay; based on preliminary

seismostratigraphic and geomorphic interpretations.

Dr. C.F.M. Lewis, Atlantic Geoscience Centre, GSC, Dartmouth – Agassiz waters; coolant for the Great Lakes and North Atlantic Ocean

Dr. R. Beukens, Isotrace Laboratory, University of Toronto – Radiocarbon dating of materials greater than 40 000 years BP, a comparison between conventional decay counting and the AMS technique.

Dr. R.M. Koerner, Terrain Sciences Divison, GSC, Ottawa – Re-examination of Greenland and Canadian ice cores: evidence for massive ice cap retreat in the Sangamon.

Dr. P.F. Karrow, Department of Earth Sciences, University of Waterloo – Status of "Interstadial" sites in southern Ontario.

Dr. J. Westgate, Scarborough, College, University of Toronto – Tephrachronology – methodology and recent research results in Alaska and the Yukon.

Dr. R.N. McNeely, Terrain Sciences Division, GSC, Ottawa – Why "hardwater" errors? ^{14}C dating of McKay Lake and more (^{210}Pb).

Dr. A.S. Judge, Terrain Sciences Division, GSC, Ottawa – Ground temperature profiles as evidence of climate change.

Dr. C. Rodrigues, Department of Geology, University of Windsor – The late Quaternary deglaciation of the central St. Lawrence Lowland and chronology of marine submergence.

Dr. J. Locat, Université Laval – Status of ADFEX - Arctic Delta failure experiment – where we are and where we are going.

REPORTS ON SECTIONS

DIVISION HEADQUARTERS

Division Headquarters, in addition to the Director's office, comprises the Scientific and Technical Services Unit, which provides editorial and cartographic services, the Administrative and Financial Services Unit, and the Secretarial and Clerical Services Unit. Also included in Division Headquarters are two Staff Scientists. One carries out studies of Quaternary geochronology in the high arctic while the other has responsibility for the Tertiary-Quaternary transition period in the Western Arctic Islands.

Field work was continued in the High Arctic, where special attention was paid to collecting datable materials from moraines of tidewater glaciers. The aim of this work is to add to our knowledge of glacier fluctuations during Holocene time and thus gain information about climatic change.

Dr. Blake, Jr. spent a sabbatical term at the Department of Physical Geography, University of Stockholm (where he is Docent), working on glacial geological data from Svalbard collected on a series of Swedish expeditions.

At the end of the report period the staff comprised 1 Research Manager, 2 Research Scientists, 2 Physical Scientists, 1 technical support, and 6 administrative support. Staff of the Division are based primarily in Ottawa with small operational units in Calgary at the Institute of Sedimentary and Petroleum Geology and in the Vancouver Office of the Geological Survey.

QUATERNARY GEOLOGY SUBDIVISION

J-S. Vincent (Chief)

The prime objectives of the Quaternary Geology Subdivision are to provide a Canada-wide inventory of surficial materials and landforms, to establish the stratigraphy and environmental history of Quaternary deposits, and to provide basic data on drift composition and provenance and on geological processes acting on the landmass.

Projects in various areas of Canada are designed to provide information on the nature and distribution of surficial materials and on terrain conditions, to determine the geologic history of the Quaternary period, to furnish an understanding of the genesis of deposits and landforms and, to develop models which will aid in prospecting for minerals.

Terrain and surficial geology information is required to elaborate policies for all land use activities in order to ensure that land resources are used economically, and that development will proceed without unacceptable deterioration of the environment. Important adjuncts of this work are preparation of regional syntheses, which explain the general nature and environmental history of Canada, and the development of expertise in terrain and environmental matters that can be tapped by other agencies. Results also provide significant input into international scientific projects such as Global Change. The ^{14}C dating laboratory has long been considered the standard for Canada and has an enviable international reputation. It continues to play an essential role in dating events which occurred during the past 40 000 years.

At the end of the report year the Subdivision comprised 17 Research Scientists, 9 Physical Scientists, and 2 supporting technicians.

GENERAL OUTPUT

During the report year much progress has been made in pursuing the Subdivision's regional Quaternary investigation programs. Memoirs with

accompanying A-series maps were completed for Cape Breton Island, Wollaston Peninsula on Victoria Island, the Tuktoyaktuk coastlands, and the Frances Lake area in the Yukon. Surficial geology map areas in western Newfoundland, the Ottawa valley, the Témiscamingue area of Québec and Ontario, Coats and Mansel Islands in Hudson Bay, the Coppermine and Mackenzie River valleys in the District of Mackenzie, the Cypress Hills of the southern Prairies and in the southern Yukon were also completed.

In total, Subdivision scientists completed and/or published a large number of manuscripts for GSC publication. Four memoirs (mentioned above), two bulletins, three papers, six Current Research papers and four open files were approved or released. Four widely acclaimed national synthesis maps portraying the Late Wisconsinan and Holocene Retreat of the Laurentide Ice Sheet and the paleogeography of northern North America from 18 000 to 5000 years ago were also produced.

Staff also published a number of contributions in outside journals: 9 papers in the Canadian Journal of Earth Sciences, 6 papers in Géographie physique et Quaternaire, 2 each in Episodes, the Journal of Radioanalytical and Nuclear Chemistry, and the Earth and Planetary Science Letters, and one each in the Journal of Geochemical Exploration, Economic Geology, Canadian Geotechnical Journal, Sedimentology and the Canadian Geographer. Scientists of the Subdivision prepared a large number of excursion guidebooks: 10 for the International Union for Quaternary Research Congress and 1 each for the International Union of Geodesy and Geophysics and Canadian Society of Petroleum Geologists. They prepared two papers for the Decade of North American Geology volume on Geomorphic Systems and 4 write-ups for the DNAG field guides. In addition five contributions were prepared for major proceedings volumes and 5 plates of the recently published Historical Atlas of Canada came from Subdivisional work. More than 60 abstracts of papers presented at various scientific meetings were also approved and published.

During the year scientists presented the results of their work at national and international scientific meetings, to universities, to other government agencies, and to industry (more than 60 oral or poster presentations). Three short courses were also prepared and given at scientific society meetings.

Quaternary Geology Subdivision personnel continued to interact with university departments by either providing support in the field and supervision of students or by sitting on theses defence committees. During the year personnel were directly involved with the work of 8 Ph.D., 11 M.Sc. and 7 B.Sc. candidates.

REORGANIZATION

At the end of the fiscal year the Subdivision was completely reorganized into three regional sections: Northern and Central Region, headed by A.S. Dyke; Western Region, headed by R.J. Fulton; and Eastern Region, headed by J.J. Veillette; a new Data Management and Scientific Services Section, headed by J.R. Bélanger; and the Geochronology Unit headed by R.N. McNeely. Restructuring was made necessary following the incorporation of the Sedimentology Research Unit, reorganization of Mineral Development Agreements within the Division and the need to address the growing problem of Quaternary data management. The restructuring along with other initiatives should among other benefits enable the Subdivision to actively respond to many of the recommendations of the Canadian Geoscience Council Advisory Committee on the GSC's ouputs in Quaternary and Engineering Geology (The Church Report).

PROGRAM HIGHLIGHTS

Nineteen scientists from the Quaternary Geology Subdivision were involved in the XIIth International Congress of the International Union for Quaternary Research (INQUA) which was held in Ottawa, July 31 to August 9, 1987. Subdivision members were active on the Organizing Committee, led field trips across Canada, presented scientific papers and acted as Chairmen for scientific sessions. This effort raised the profile of the Geological Survey of Canada in the International community as almost 1000 participants attended and the Congress was an unqualified success.

On the occasion of INQUA, the journal Gø øgraphie physique et Quaternaire prepared a special issue on the Inception, Growth and Decay of the Laurentide Ice Sheet. R.J. Fulton in conjunction with J.T. Andrews acted as "ad hoc" editors and 7 members of the Quaternary Geology Subdivision wrote more than 60% of the text. The exceptional synthesis maps of A.S. Dyke and V.K. Prest were also included in the issue. Among many contributions the special volume proposed new models and ideas on the ice sheet which will serve to direct Quaternary research in Canada over the next years.

Geophysics and Terrain Sciences Branch convened a workshop on Neotectonics in Canada. Officers of QGS presented regional overviews of Cenozoic tectonic and physiographic evolution in the Cordillera, the Arctic Archipelago, and the Appalachians, while case studies illustrated particular postglacial tectonic features on Victoria Island and on the Shield. Holocene sea level studies in all regions have provided the best data on postglacial tectonism, including a record of block movement in the Arctic.

R.J. Fulton met in Leningrad with the Soviet leader of project 1.2 of the Canada/USSR Program of

Scientific and Technical Cooperation in the Arctic and the North. The objective of this project is to publish a 1:10 000 000 scale Quaternary geology map of the area north of 64°. The main results of the Leningrad meeting were agreement on a legend and the division of compilation duties for areas that are neither Soviet nor Canadian. Canada will be responsible for the region from the East Greenland Shelf to the Chukchi Sea and for the Arctic Ocean basins adjacent to Canada.

NORTHERN SECTION

Detailed paleomagnetic investigations of the Duck Hawk Bluffs on southwestern Banks Island have confirmed that the Brunhes/Matuyama boundary (730 ka) is located within the Morgan Bluffs Formation interglacial sediment suite. The results also indicate that the Banks Glaciation, the oldest well defined ice advance in the southwestern Arctic Archipelago, is of Early Pleistocene age. On the basis of the paleomagnetic and paleoecological results it is also likely that the preglacial Worth Point Formation is of Late Pliocene age.

The need for Quaternary studies on the northwest Queen Elizabeth Islands was appraised in the field on Prince Patrick Island. The scattered glacial deposits apparently are clues to speculated inundation by an Early(?) Pleistocene continental ice sheet, to impact of Wisconsinan ice sheets and to extent of locally generated glaciers. Holocene delevelling and sea level change are not straightforward, and need study.

A major finding of fieldwork on Victoria Island was the discovery of two series of datable materials in a valley with elevations ranging from near sea level to near marine limit. The Point Caen series from southwestern Wollaston Peninsula will supply an emergence curve for the area and help define the ice dynamics in the Dolphin and Union Strait area. Another site at Hadley Bay also includes a range of elevations and materials (shells, driftwood, whalebone, and peat). This series should help define ice dynamics in an area of complex late- glacial flow on northeast Victoria Island. Widespread areas of exposed bedrock in southeast Victoria Island show evidence of peculiar sculpted erosion forms thought to be related to erosion by subglacial meltwaters. These features suggest widespread wet-based glacier conditions and release of subglacial water as possible floods.

The Tertiary Beaufort Formation on Prince Patrick Island has been confirmed to be a single distinctive stratigraphic unit. They were deposited by braided rivers at a time when boreal forest and forest-tundra conditions existed. Post-Beaufort sediments, possibly of Pliocene and/or Early Quaternary age were also identified. Information from here and Banks Island will enable scientists to reconstruct Arctic paleoenvironmental conditions prior to the onset of continental glaciations.

Identification of extremely long, narrow carbonate drift dispersal trains on Melville Peninsula suggests that ice streams made up part of the Laurentide Ice Sheet in this area. Results from this area, and other parts of the Shield suggest that the dispersal train concept used in drift prospecting may have very limited applicability to modelling ice sheet dynamics. New models are being developed as a result of these findings.

Systematic mapping in the Coppermine River region since 1979 will result in the publication of a Quaternary map (1645-A) covering the area between Parent Lake and Coronation Gulf. The 1/250 000 scale map incorporates the following N.T.S. areas: 86 G Redrock Lake, 86 J Hepburn Lake, 86 O W½ Coppermine and 86 N Dismal Lakes. A series of Late Wisconsinan sediment, up to 60 m thick, occupies parts of the Coppermine River bedrock valley. The sequences can be grouped into five morphosedimentary zones that represent the following environments: glacial, paraglacial, lacustrine and marine. This complex, often interfingering, suite of sediments constitutes a continuum of episodic deposition in time transgressive environments related to ice frontal positions. Glacial and paraglacial sediments were in part reworked into a glaciolacustrine suite extending from delta topsets of bouldery gravel to bottomset rhythmites of silt-clay. The latter, up to 40 m thick, formed the matrix of a later sequence of debris flow events which emplaced a wedge of massive diamictons in the postglacial marine silty rythmites. This sequence of terrestrial sediments interbedded with marine sediments is possibly the best documented Quaternary olisthostrome.

EASTERN SECTION

A new project directed at detailed surficial mapping, glacial transport, ice flow indicators and till stratigraphy was initiated in the mining area of western and central Abitibi. The glaciation-deglaciation model proposed for the Timiskaming-Abitibi area, developed as a result of earlier work, is supported by provenance data provided by overburden drilling programs, and is currently being used by mineral exploration companies.

Systematic terrain mapping in western Newfoundland has brought to light numerous areas of mountainside sagging, a hitherto unrecognized hazard in eastern Canada. This process of large-scale, deepseated gravitational creep is causing debris flows and landslides, one of which recently occurred in Gros Morne National Park. The discovery permits outlining areas of future slope stability problems and, following meetings with park officials, resulted in changes to public policy and operations.

Research on postglacial sea-level recovery in the Atlantic region shows a widespread rapid rise linked to crustal subsidence and tidal change. The submergence of 20-50 cm per century is the fastest in eastern North

America and is the prime determinant of present shoreline change. Measured erosion rates average several metres per year and are predictable. The understanding improves assessment of economic impact and planning of remedial measures.

Detailed terrain mapping in northern Newfoundland resolved a problem of iceberg hazard assessment. Mapping of submarine landforms in the proposed Strait of Belle Isle hydroelectric corridor had revealed linear features, thought by some to be modern iceberg furrows, but comparison with the adjacent formerly submerged land area showed that the features were ancient glacial formations (De Geer moraines) and that there was no evidence of impact by floating ice.

N.R. Gadd continued to act as editor for the production of a special Geological Association of Canada volume on the Champlain Sea. This volume will provide a long awaited synthesis of our knowledge on this important postglacial sea.

WESTERN SECTION

A number of sections containing nonglacial deposits dating from the interval between McConnell and Reid glaciations were located along the Pelly River, Yukon Territory. One of these exhibited three phases of ice wedge pseudomorphs, peats and possibly a tephra.

Further excavation was conducted at the Ketza River site in the central Yukon. Bison, mammoth, horse, moose and ground squirrel remains have been identified from this locality. This is the only place where vertebrate remains have been found in sediments underlying Late Wisconsinan-McConnell Glaciation till.

New exposures along the Stewart River, Yukon Territory, include extensive organic deposits which have yielded the first finite radiocarbon date of pre McConnell Glaciation age.

Paleosols, including a prominent calcrete horizon have been discovered in loess on the upper surface of the Cypress Hills. These could potentially provide a record of climatic change and process activity that will reach back to Pliocene time.

Field checking on the northern Cordilleran Mountain Front confirmed that moraines of the penultimate montane glaciation of Mackenzie Mountains are truncated by the all-time limit of the Laurentide Ice Sheet; moraines of small montane glaciers postdate the maximum stand of Laurentide ice; large valley glaciers that headed in the Backbone Ranges of Mackenzie Mountains merged with the Laurentide Ice Sheet after the latter had begun to retreat. These relationships are providng new insight on the chronology of glaciation in northwestern Canada.

Field investigations were conducted in the vicinity of the Sandspit and Rennell Sound faults on the Queen Charlotte Islands in an attempt to find evidence of Holocene movement. No evidence of movement was found but the forest cover and shattered nature of the rock over relatively broad fault zones make detection of discrete dislocations difficult. Additional data, related to past sea level, was collected on Graham Island in order to further refine our knowledge of Holocene changes. Some of the evidence collected appears to indicate that sea level changes were similar on all sides of the island. This conflicts with current ideas that the Queen Charlotte Islands are being tilted. The goal of this work is to determine the nature of neotectonic movements in the coastal areas of British Columbia as an aid to predicting the likelihood of mega thrust earthquakes.

MINERAL EXPLORATION SECTION

Infrared spectroscopy and transmission electron microscopy have been applied to the study of clay minerals precipitated at and near the surface at a vent site where black smokers are presently active in the sediment-covered axial valley of northern Juan de Fuca Ridge. Expandable clay, identified as the Mg- rich smectite, saporite, is microlaminated with stringers of polymetallic sulfides, mainly chalcopyrite, which supports an elevated temperature of smectite formation, possibly >250°C. Infrared techniques complement X-ray diffraction and electron microprobe examination and provide useful information to aid in distinguishing between clays formed by continental weathering processes and clay formed by direct precipitation due to hydrothermal processes.

Major sessions of papers on drift prospecting were organized for the Canadian Institute of Mining and Metallurgy annual meeting and for the INQUA Congress. Several of these papers will be published in a GSC volume on drift prospecting. A major review paper has been prepared on progress in the last decade in geochemical exploration in glaciated terrain, to be published in the Exploration '87 volume. These publication efforts are part of long-standing interdisciplinary work by staff of Mineral Resources and Terrain Sciences divisions.

Research continued into the clastic and geochemical behaviour of gold and platinum group elements in till and soils. Palladium, for example, seems to behave like a mobile base metal, whereas platinum seems resistant to weathering, as expected.

A program of follow-up sampling was conducted in the Frontenac Arch area, eastern Ontario, in areas known to be enriched in selected trace elements. The purpose of this work was to further delineate and characterize chemically those areas that are potentially the most sensitive to the effects of acid rain.

GEOCHRONOLOGY LABORATORY

Terrain Sciences Division personnel, with Quaternary geology expertise in the major regions of Canada, comprise a Geochronology Committee which vets all samples submitted for dating; monitors all contractual arrangements with other dating laboratories; and provides advice to the Director on how the Laboratory can best meet its objectives as a National resource laboratory.

The Radiocarbon Dating Laboratory, now in its 28th year of operation, has dated in excess of 4600 samples. The recently implemented computer data base allows the efficient generation of information on samples for the Laboratory's clientèle. These data can be electronically transferred to the Publication Division for inclusion in the annual 'Date Lists' and other publications. The 3000 published GSC dates are now accessible on the GSC 'Date Locator File' (radiocarbon data base) for use by the scientific community. The Laboratory also provides the Canadian component to the 'Global Radiocarbon Data Base' maintained by the journal Radiocarbon.

Determinations completed

Conventional radiocarbon ages (GSC)	
Geological samples	206
$^{13}C/^{12}C$ ratios (University of Waterloo - contracts)	205
AMS radiocarbon ages (IsoTrace) (University of Toronto - contract)	32
Conventional radiocarbon dates on bone (Saskatchewan Research Council - contract)	23

INFLUENCE

Besides the important influence Subdivisional staff has exerted through the written and oral presentation of its data, scientists have been involved in the evaluation and often monitoring of numerous research grants and contracts. During the year some 32 EMR Research Agreements, 6 NSERC grants, 3 NSF grants and 1 Ontario Geoscience Research Grant were evaluated. In addition critical reviews of more than 40 journal and 20 internal contributions were provided.

During the year scientists continued in numerous instances to provide advice and information to industry, universities and other government agencies on a wide variety of topics: location of specific granular resources as suitable sites for construction of energy transportation corridors; drilling methods of Quaternary deposits particularly in frozen ground; models of Quaternary ice flows in specific areas as an aid to mineral exploration. Results from till and other analyses have led to or stimulated mineral exploration in various parts of Canada, particularly in the clay belt, in northern Manitoba and in the Yukon.

Finally through their responsibilities in various scientific societies, journal editorial boards, and committees scientists of the subdivision have played a leading role in promoting Quaternary geosciences.

FEDERAL-PROVINCIAL RELATIONS

Terrain Sciences Division continues to be heavily involved in the Mineral Development Agreements (MDA) with Newfoundland, Nova Scotia, New Brunswick, Ontario, Manitoba, and the Northwest Territories. Most of the projects underway are investigating field areas of bedrock that are favourable for ore deposits, but that are also extensively drift-covered. These projects are concerned mainly with determining the distribution, history, and provenance of glacial drift and with demonstrating the use of the geochemistry of glacial drift in mineral exploration. Studies of till geochemistry, and surficial mapping emphasizing the lithology of tills and the sequences of ice-flow events, have already provided promising additions to the geoscience database in areas that are being investigated by mineral exploration companies.

Most of the MDA's are now entering their last year, during which their final reports will be produced. Many interim reports were presented in 1987-88 in the form of articles in Current Research, lectures, and poster displays. Several of the project leaders were invited to speak about their results at the Canadian Institute of Mining and Metallurgy annual and branch meetings, at the International Union for Quaternary Research Congress, at the Prospectors and Developers Association annual meeting, and at universities. A group of papers from the MDA projects will be published in a special GSC volume on drift prospecting.

In the Newfoundland MDA, maps have been completed showing glacial landforms, and a complicated record of ice-flow events for large parts of Labrador. Fieldwork in 1987 has documented complex Quaternary stratigraphy in the Wabush area. Sections there contain evidence of several glacial events and an old nonglacial episode, which were previously unknown in this part of Canada.

The till geochemistry project of the New Brunswick MDA has been concentrating its efforts on the central and northern part of the province, particularly in the Miramichi zone. Two thousand samples were collected over three 1:250 000 map sheets. Areas of metalliferous till have been defined; the higher priority ones for follow-up work are those for gold and tin.

The Ontario Mineral Development Agreement program of the Division consists of five projects spread across the province from the eastern Frontenac Arch to the Timmins-Smoky Falls area, to Beardmore-Geraldton, and to Lake of the Woods.

Mapping and till geochemistry studies continued in the Frontenac Arch, Beardmore-Geraldton, and Lake of the Woods projects. Stratigraphic and provenance studies based on analysis of drill core were the main activities of the Beardmore-Geraldton and two Timmins area projects. Data on the gold content of till from the Beardmore-Geraldton project have stimulated new exploration in the area.

Drilling in the Timmins area has identified a widespread fossiliferous nonglacial unit, the Owl Creek beds, separating tills above it having little value for drift prospecting from tills below it that have as yet unknown provenances, but are useful for drift prospecting. The nonglacial beds probably record the last interglacial and can serve as an analogue for the present one.

Farther north, a similar complex sequence was drilled in an effort to correlate the stratigraphy in the Hudson Bay Lowlands with that in the Timmins camp. Geochemical and lithological analysis of the tills sampled in the three drilling projects is being performed to aid correlation and provenance estimation, which are crucial data in drift prospecting in these regions.

Surficial geology mapping continued in the Manitoba MDA in the northeastern and northwestern parts of the province. Several maps have been approved for publication. Till geochemical studies were concentrated in the Lynn Lake-Leaf Rapids-Flin Flon region, mainly following up anomalies found in previous years and completing detailed studies around belts of rock known to be favourable for mineralization. Two companies took out exploration permits in the Wheatcroft Lake area in response to publication of a study on gold and arsenic anomalies in till in that region. Follow-up work within the Osik Lake ultramafic dispersal train was done to find the source of high gold concentrations in several samples of till.

Backhoe sampling of gold-bearing glacial Lake Agassiz beach sands and underlying till at Manigotagan, Manitoba attempted to identify the sedimentologic controls on these placers. Till up-ice of the site was found to contain elevated gold levels, suggesting reworking of gold during the fall of Lake Agassiz water level. The ultimate bedrock source of the gold is unknown.

The first year of the Northwest Territories MDA saw the Division start one project, on Quaternary geology and till geochemistry in the Kaminak Lake area, District of Keewatin. A large number of archived samples from the Rankin-Ennadai greenstone belt were reanalyzed for 32 elements, in order to identify which areas show the most promise for gold, PGE, and lithophile element mineralization.

GEOLOGY OF CANADA (DNAG)

At the end of the fiscal year 11 of the 14 chapters of the Quaternary Geology of Canada and Greenland volume had been edited, checked by authors, had figures drafted and had been submitted for French translation. Of the remaining three chapters, only one was with the author for further revisions. This volume is one of Canada's contributions to the geology of North America series, that is being prepared to commemorate the 100th anniversary of the Geological Society of America.

REGIONAL MINERAL DEVELOPMENT PROGRAM AND GASPE INITIATIVE

(1) Surficial Geology Mapping Program

Started in 1985 the program's initial objective was (1) to complete the 1:50 000 mapping program initiated by MERQ and (2) to produce a 1:250 000 surficial geology map for the entire Gaspésie Peninsula. This map is seen as a logical complement to similar maps now available for New Brunswick and the state of Maine, U.S.A. In 1987 this compilation exercise was extended to cover the lower St. Lawrence west of the Matapø ødia River area, where another surficial geology map compilation has been undertaken.

Field work, shared between the project leader and Cogéo, Inc. under contract, was completed in 1987 for the Gaspésie map area and initiated for the lower St. Lawrence map area. Compilation of the Gaspésie map is proceeding on schedule and will provide, for the first time, a detailed picture not only of the distribution of glacial deposits, but also of the main directions of ice flows, distribution of lithological indicators of glacial transport and the age and position of the marine limit.

Two preliminary surficial geology maps, at a scale of 1:50 000 were released on Open Files and two papers in the Current Research series were published.

Information has been provided to individuals and companies engaged in mineral exploration, in particular to a company involved in lead exploration in the Ste Anne des Monts area, and to one involved in heavy minerals studies in the Causapscal area.

The compilation has served among other benefits to recuperate the results of years of surficial geology mapping by the MERQ which has recently abandoned its Quaternary program.

(2) Glacial Dispersal Program

A detailed sedimentological, geochemical, lithological and glacial transport analysis of the McGerrigle granite boulder train constitute the objectives of this project. The principal investigations are Dr. P.P. David and graduate student P. Bédard of the Université de Montréal. Fieldwork was carried out in 1985 and 1986, and a GSC bulletin outlining the results obtained will be submitted in July 1988. The

report period was allocated to analysis of data and report writing.

Two Current Research papers, and a poster presentation, at the GSC Current Activities Forum detailed up to date progress

Results obtained have already been used to correct or validate rock units established from bedrock mapping programs and to explain geochemical anomalies apparently unrelated to bedrock geology. Extensive trenching has demonstrated that preglacial colluvium is locally an important surficial geology unit. The program stresses the importance of a sound knowledge of glacial stratigraphy in the interpretation of the glacial history.

The project is generating two M.Sc. theses, and a Ph.D. thesis at the Geology Department of the Université de Montréal.

MINERAL EXPLORATION TECHNOLOGY - DRIFT PROSPECTING METHODS

Reconnaissance and detailed-scale till sampling continued in Labrador, New Brunswick, Ontario, and Manitoba as part of Mineral Development Agreements. Geochemical and lithological analysis will aid in determining the provenance and background composition of the till and will demonstrate drift prospecting methods in a variety of geologic terranes that have known mineral potential.

Studies of Quaternary stratigraphy in Labrador, New Brunswick, and northern Ontario have shown that the geologic record is more complex than was initially expected. In some mining districts (e.g. Timmins, Wabush), very old glacial sediments and fossiliferous nonglacial beds are preserved. These sequences provide stratotypes for investigations of the provenance of tills when drift prospecting is carried out in the search for new ore deposits.

Continuing work on the residence sites in till and soil of gold, platinum group and other elements has shown that many of these trace elements are preferentially enriched in specific grain size ranges, depending on the mineralogy and weathering history of the samples. The study of the shapes and compositions of gold grains from glacial sediments in northern Ontario and southeastern and northwestern Manitoba shows that glacially abraded gold grains have been heavily corroded during the short time since deglaciation, about 9000 years. Tiny gold crystals have been found in till at one locality; work is underway to determine if these are detrital or authigenic.

TERRAIN DYNAMICS SUBDIVISION

J.A. Heginbottom (Chief)

The Terrain Dynamics Subdivision comprises three sections: Geomorphic Processes and Engineering Geology, headed by D.G. Harry; Permafrost Research, headed by A.S. Judge; and Terrain Geophysics, headed by J.A.M. Hunter. The responsibilities of the Subdivision are the provision of geoscientific information on: geomorphic processes active within Canada; geotechnical and engineering geologic properties of near-surface earth materials, particularly as they may affect human use of the terrain; geophysical properties of near-surface earth materials, particularly with regard to geotechnical and engineering concerns and the distribution of surficial geologic materials; geological hazards and constraints to development, both catastrophic and chronic, as they relate to surficial materials and geomorphic processes; and the development of geophysical and geotechnical equipment and techniques to assist in undertaking the foregoing tasks. A substantial proportion of the work of the Subdivision is undertaken in northern Canada, and particularly in areas underlain by permafrost. Work is also undertaken in offshore areas, again primarily in northern Canada.

The Subdivision receives substantial financial and staff resources from non-A-Base sources within the Department and from Indian and Northern Affairs Canada. In 1987-88 support was received from the Panel on Energy Research and Development for research related to northern hydrocarbon transportation, particularly the problems of terrain stability and pipeline right-of-way performance in a permafrost environment, and the hazards to hydrocarbon exploration and production posed by natural gas hydrates. Support was also received from the Northern Oil and Gas Action Program (INAC), the Frontier Geoscience Program (EMR), and the Federal Nova Scotia Mineral Development Agreement. In addition, Indian and Northern Affairs Canada provided partial funding and field support for projects to examine terrain performance along the right-of-way of the Norman Wells-Zama oil pipeline.

Research facilities available within the Subdivision include a laboratory for precise determinations of the geothermal properties of rocks and surficial materials, four cold rooms, general laboratories, workshops for the construction and maintenance of geophysical equipment, and a wide range of computer equipment for laboratory, field and office use. Specialized geophysical field instruments and laboratory equipment are available.

Terrain Dynamics Subdivision comprises three Sections, each with a distinct focus and operating style. Accordingly this report is subdivided into three parts, one for each Section. Each Section is identified as a "Sub- Activity".

At the end of the report year the Subdivision comprised 9 Research Scientists, 5 Physical Scientists, and 6 technical support.

GEOMORPHIC PROCESSES AND ENGINEERING GEOLOGY SECTION

Work during 1987-88 in northern Canada comprised various studies related to permafrost and ground ice and periglacial processes. In southern Canada, work was limited to studies of landslides in the Cordillera, and a small amount of periglacial geomorphology in Newfoundland.

Work continues on the distribution and character of permafrost and on ground ice as a geological material in several regions of Canada. A manuscript map (scale 1:1M) of ground ice in northwestern Canada, reinterpreted from surficial geological maps and field observations was completed.

Periglacial process studies on southern Victoria Island have identified an interesting thermokarst landscape and significant evidence of neotectonic earth movements.

Studies of landslide hazard in the Canadian Cordillera continued, with field work at several sites in southern British Columbia. This work contributed to an INQUA field excursion, and technical advice was provided to private sector consultants, municipalities, and B.C. Government agencies. This work has resulted in 1 journal paper, 3 conference publications and 6 reports in press. A contract, resulting from an unsolicited proposal, was arranged with Thurber Consultants Ltd. of Vancouver for a study of rockfalls leading to a computer model of rockfall tracks, which may be suitable for developing hazard zonings for sites subject to rockfall. A report was received.

TERRAIN GEOPHYSICS SECTION

Field research in 1987-88 comprised various shallow seismic surveys in co-operation with several agencies, both GSC and non-GSC; and the development and testing of new items of field equipment.

Field surveys were undertaken at Sussex Corners, New Brunswick (with New Brunswick Department of Mines); Pointe Fortune, Quebec (with J.J. Veillette, TSD); Quyon, Quebec (internal); the Rainy River-Fort Francis area, Ontario (with Ontario Geological Survey), Val Gagné, Quebec (with G. Palacky, MRD); Matheson, Ontario (with Ontario Geological Survey); and Fraser River Delta, British Columbia (with Cordilleran Division).

Field tests of a new, Canadian made, engineering seismograph (Scintrex Echo 5-2) were carried out. Instability problems were reported to the manufacturer; they have been corrected and the final version has been well received. A new, downhole shotgun seismic source was field tested and a confidential report provided to the manufacturer. Preliminary tests of a new technique for detecting shear waves was begun.

A new approach to marine seismic refraction surveys, the "vertical refraction array", was developed and preliminary tests conducted in the Beaufort Sea and the Ottawa River. Initial results were very promising and further development and testing is planned. The technique may be particularly valuable for conducting surveys, especially common depth point soundings, in ice covered waters.

The foregoing work resulted in 3 conference publications, 2 confidential reports and preparation of 2 GSC Open File reports. In addition, a set of lecture notes for a field school was prepared and field demonstrations of shallow seismic reflection techniques were given on several occasions.

PERMAFROST RESEARCH SECTION

Field work in 1987-88 comprised temperature logging of 1 new oil well, relogging of 20 wells and reading ground temperatures from 9 shallow cables in the western and high arctic. In addition several new wells were located and well abandonments were organized. Three new cables were installed near Yellowknife and Norman Wells for climatic change studies.

Laboratory work included determination of thermal properties on over 2800 samples, several thermistor calibrations, and construction, maintenance and modifications of field and laboratory instruments and special test equipment. Development of specialized software for data loggers, data handling and laboratory instrumentation continues. New equipment was ordered and tested. Specialized data processing was carried out.

The work resulted in 5 publications (1 journal paper, 1 journal paper accepted, 2 conference presentations and 2 contributions to GSC MR 40), and advice was provided to numerous people and agencies on ground temperature and thermal properties measurements.

FRONTIER GEOSCIENCE PROGRAM

Three distinct activities were undertaken with FGP support during 1987-88. Each is reported on separately.

1. Ice Island seismic reflection studies

The data gathering componant of the Ice Island seismic reflection experiment was suspended early in the fiscal year, as the Ice Island had not moved across areas of interest in 1986. During the season, the Island moved favourably and plans were made to resume data

gathering in 1988-89. Over the winter, considerable movement of the Island occurred and the resumption of data gathering was advanced to 1 March 1988. Maintenance of the facilities was undertaken during 1987. Processing of data from 1985 and 1986 continued under contract. Early returns of data from March 1987 were processed in March as part of a strategy for determining the future of the experiment. The work contributed to 1 journal paper and 1 conference presentation. Two major seismic data processing contracts continued.

2. Geomorphic Processes, Mackenzie Valley-Arctic Coast

Work, undertaken on contract by J.R. Mackay, University of British Columbia, comprised investigation of growth and decay of permafrost and ground ice at some 10 sites in the Mackenzie Delta and Tuktoyaktuk coastlands area and a review of selected aspects of the origin of ground ice (massive ice, injection ice, glacier ice). Two reports were submitted and the work contributed to some six publications (4 journal papers, 1 conference presentation, 1 Current Research paper).

3. Studies of 1985 North Nahanni (English Chief) Rock Avalanche

A joint GSC-University of Alberta research team completed field studies in July. Data on rock mass characteristics and the nature of the rupture surface were collected and analytical work was continued. The work contributed to 2 journal papers and 2 conference presentations.

ENERGY RESEARCH AND DEVELOPMENT PROGRAM (Task III and VI)

Resources from the Energy R&D fund are used to (1) accelerate research which would otherwise be supported by the A-base program, (2) supplement this research with work more directly related to energy concerns, particularly energy transportation, and (3) support some special research, of general interest to the energy program, but which would not otherwise be contemplated under the A-base program. The resources received by the Subdivision comprise 1 PY from Task III, and 1 PY and (in 1987-88) $1,200,000 in operating and capital funds from Task VI. The Task VI funds are allocated under Program 61: Permafrost and Gas Hydrates.

The funds are disbursed partly by means of contracts for research and services, and partly to provide operational support for GSC projects. In the latter case, most of the staff time is provided from the A-base program of the Subdivision.

Work under the permafrost part of this program comprised a suite of field, laboratory and office studies into the distribution, properties and research techniques related to permafrost and ground ice. Field studies were concentrated in the Mackenzie-Beaufort area, but with some work in the Arctic Islands and northern Quebec. Laboratory work was supported in Vancouver, Calgary, Waterloo, Ottawa, Montreal, and at Caen, France.

A large, multidisciplinary (geology, geophysics, geocryology and geotechnique) investigation was carried out in the shore-zone of Richards Island, N.W.T., as part of an ongoing study of the shore-zone of the Beaufort Sea in preparation for a possible pipeline landfall. Field work was undertaken in April and August, and the preliminary results released as an Open File report. The results have also contributed to some 10 other publications (conference presentations and journal papers).

A 2nd generation deep-tow eel for high resolution, marine, refraction seismic surveys to detect shallow ice-bearing and ice-bonded permafrost in continental shelves was constructed, and was deployed and tested from the C.C.G.S. NAHIDIK in the southern Beaufort Sea in September. About 2850 seismic records were obtained and are being analyzed under contract. Data were obtained from areas of interest for hydrocarbon development in the Amauligak-Isserk area.

The field phase of studies at the former Calgary pipeline test loop were completed during the year. Data analyses and report writing continues. Test pipeline research at CNRS Caen, France, continues under contract by Carleton University.

Development of ground probing radar as a high-resolution geophysical profiling research tool for the study of permafrost and ground ice continued. Field surveys were undertaken on Richards Island, N.W.T., and in northern Quebec. Contracts were arranged for development of a time domain reflectometry unit to be used with the existing radar data module, and for the development of a capacitance meter. This work has contributed to a GSC Open File report and two conference presentations. Results will also be presented at the forthcoming EMR- sponsored workshop on ground probing radar (May 1988).

Three field research contracts with Queen's University (2) and UBC (1) related to studies of frost heave were supported during the year, resulting in contract reports and in contributions to conference presentations.

Laboratory research contracts were arranged with University of Waterloo for a continuing study of ice segregation in freezing saline soils, and with École Polytechnique, for a continuing study of the borehole dilatometer relaxation test as a method for the in-place determination of the mechanical properties of frozen soils. Contract progress reports were received.

A contract was arranged with M.W. Smith Geosciences Ltd. for a report on laboratory test procedures for the determination of the unfrozen water

content of frozen soils, for inclusion in a manual of laboratory test methods for permafrost soils. Two other Sections, dealing with thermal properties and dynamic properties were edited for publication, also under contract, by Gilpen Editing Service. A contract for compilation of data on the mechanical properties of permafrost soils was arranged with Thurber Consultants Ltd. of Calgary. Progress reports for each of these were received.

Several proposals for new projects to be considered for Energy R&D funding in the future were developed and circulated for peer review.

GEOLOGICAL CONSTRAINTS AND HAZARDS TO DEVELOPMENT

Work related to geological hazards during the year comprised continued study of landslide hazard in the Canadian Cordillera, with field work at several sites in southern British Columbia and the completion of the field component of the English Chief (North Nahanni) Rock Slide, Mackenzie Mountains, N.W.T. The work was supported under the A-base program and the Frontier Geoscience Program, and is reported on more fully elsewhere. In addition, a field study of landslide hazard at selected sites in southwest China was undertaken, theoretical work on the magnitude and frequency of landslide events was continued, and plans were made for participation in the International Decade for Natural Hazard Reduction and for studies related to the terrain response to a possible very large earthquake in southwestern British Columbia.

Considerable work was undertaken on all aspects of permafrost science, ground ice and periglacial geomorphology. In particular, studies related to hydrocarbon developments and infrastructure construction in the Beaufort Sea area and the Mackenzie Valley were continued. This work was funded largely by PERD, but with additional support from A-base, FGP, NOGAP and from Indian and Northern Affairs Canada. The work is reported on fully elsewhere.

NORTHERN OIL AND GAS ACTION PROGRAM (NOGAP)

The third year in a five-year research program was completed as scheduled; the project complements work being undertaken by P.R. Hill (AGC). Field work was carried out in April, in conjunction with work supported by Energy R&D Program, Task VI, and in July to September. Field work concentrated on investigations of terrain conditions, ground ice occurrences, Quaternary geology, engineering geology and ground thermal conditions of nearshore and onshore areas. Laboratory studies examined ice petrography and isotopic analyses, for determination of age and origin of ground ice, and textural and mechanical properties analyses of sediments. The work contributed to 5 publications (3 conference presentations, 1 journal paper, 1 GSC Open File report). Four small contracts for sample analyses were completed.

INDIAN AND NORTHERN AFFAIRS CANADA (INAC)

Resources were received from INAC in support of two research projects.

1. Permafrost Research: Norman Wells pipeline right-of-way

Work continued with three pipeline monitoring trips during the year and continued automatic data collection, with one additional data logger installed.

Data reduction and analysis continued and work on major INAC progress reports continued. The project resulted in 1 internal report, 1 GSC Open File report, 1 conference proceedings paper (in press), 1 conference presentation, and 3 presentations to INAC (NOGAP Committee and Norman Wells Pipeline Monitoring Group). Four contracts, supported under this program, were completed.

2. Investigation of Frozen Core Tailings Dams, Lupin Mine, Contwoyto Lake, N.W.T.

Thermal and ground probing radar studies were carried out at the site in April, with drilling and instrumentation of additional sites done in September. Thermal and radar data were analyzed and interpreted in-house and by contract. The project resulted in 4 conference presentations or proceedings publications and 1 Current Research report. One contract was completed.

MULTI AGENCY GROUP FOR NEOTECTONICS IN EASTERN CANADA (MAGNEC)

Two contracts were arranged, jointly with O.G.S. One provided for a field survey, map and report of neotectonic features in Prince Edward County, Ontario. The second funded drilling and coring of a borehole within the mapped area. No publications were released.

QUATERNARY ENVIRONMENTS SUBDIVISION

B.R. Pelletier (Chief)

The following is an account of the significant contributions of the Quaternary Environments Subdivision during the reporting year, 1987-88. This report covers the activities of the Subdivision under its three operating sections: Administration, Paleoecology Section, headed by T.W. Anderson, and Glaciology Section, headed by R.M. Koerner. At the end of the report period the Subdivision comprised of 8 Research

Scientists (RS), 3 Physical Scientists (PC), 9 Technical support (EG-ESS), and 1 Postdoctoral Fellow.

Activities of the Subdivision this year were focussed on participation in the INQUA Congress held in Ottawa during mid-summer of 1987. The entire scientific staff were involved as follows: full attendance, presentation of 8 poster sessions and 15 talks, leadership of 5 field excursions and joint preparation of 6 field guidebooks.

Throughout a series of seminars and meetings of the Subdivision it became apparent that a viable potential was available for contributing to the proposed Global Change Program. It is the direct applications of the results of the field and laboratory results that are significant, in that modellers of global climate patterns can utilize this information in predicting future climates from a study of past trends. Those working in paleoenvironments have the best and most cogent data to offer because they are able to interpret these ancient settings from analyses of proxy climatic indicators such as pollen, peat, vegetation and isotherms, sealevel fluctuations and glaciation phenomena. Evidence of the drill cores from the ice caps offers even greater control on modelling exercises because workers deal with temperatures obtained from determining elemental ratios such as oxygen isotopes, from minute portions of trapped atmospheres by snowfalls and now encased in ice, from recently deduced seasonal fluctuations in pollen, from mass balance of the ice itself and from examination of numerous aerosols now trapped in the glaciers. It is possible to speculate on trajectories of these particles, and their sources. Most important, the dating of this material, and the determination of the ancient temperatures, permits time-temperature curves to be drawn, from which climatological cycles and trends can be drawn and possibly used in predictive models on a global scale.

During the year all scientists published accounts of their material which amounted to about 35 items in all of which 15 were co-authored. These included 4 papers in outside journals, 22 abstracts published in Proceedings of various meetings and conferences, 6 field guidebooks, and 2 GSC reports and 1 map. Nearly 80 internal service reports were submitted for various project leaders. The second folio of the Marine Science Atlas of the Beaufort Sea: Geology and Geophysics was published, and appears in advance of the anticipated commercial development of the oil fields discovered in the southern Beaufort Sea. It is interesting that contributions arrived from 6 Divisions of the GSC, and several from outside federal agencies and the Canadian petroleum industry.

ADMINISTRATION

Administration includes both Paleoecology and Glaciology sections, and the supervision of the Divisional Sedimentology Laboratories. Much of the resources were applied to the Sedimentology Laboratories, and a lesser amount to continuing work on two office projects.

In the Sedimentology Laboratories, the main emphasis has been on sample preparation for geochemical and textural analyses of sediments collected on the field parties operated by Division staff. These operations and volume of work are listed in Table 1. The analytical results support the reports written by workers carrying out terrain and Quaternary geology mapping projects, engineering and geomorphological studies, environmental programs relating to both modern and ancient settings, and mineral tracing studies to assist in economic development of given regions. Approximately 35 field projects were supported through these laboratory services.

Table 1. Operations of Sedimentology Laboratories

a. Engineering

	Operations/Determinations	Samples
1.	Freeze drying	1384
2.	All textural analyses	3417
3.	Hygroscopic moisture content	1422
4.	Atterberg limits	217
5.	Calcite/dolomite ratios	368
6.	Natural water content	76
7.	Munsell colour	243
8.	Bulk density	73
9.	Specific gravity	62
10.	Retrieved, bottled and labelled fraction for heavy mineral separation	158
11.	Retrieved, bottled and labelled suspension fromgrain-size analyses	53
TOTAL		7473

b. Minerals

	Operations/Determinations	Samples
1.	Clay separations	564
2.	Clay slides	101
3.	Total carbon	1493
4.	Organic carbon	1493

Table 1. (cont'd)

5.	Wet sieving	828
6.	Dry sieving	787
7.	Heavy mineral separation	157
8.	Heavy mineral slides	296
TOTAL		5719

Part of the Administration involves the Scientific Authority of a commercial contract, which deals with the preparation, coding and cataloguing of samples for geochemical analyses to the firm Chemex Ltd. of Vancouver, British Columbia and Mississauga, Ontario. The contract serves MDA projects (Mineral Development Agreements) established with federal and provincial governments, as well as A-Base projects throughout Canada. This service is a vital function of the laboratory, as the latter is the receiving and transshipment point of 7000 field samples, sample splits, analytical results and other related material and documents in the laboratory. A flow chart of sample operations has been designed to assist the contract users.

In the engineering area, a core X-ray machine has been installed and preliminary tests have been run. The next phase will be to train the operators so that production runs can be established. This will be followed by the installation of computer facilities so that all X-ray logging can be handled automatically. Analyses of cores for texture, stratigraphy, density and porosity will facilitate environmental engineering studies in areas underlain by permafrost and unstable soils.

Both office projects involving map production are drawing to a close. The Quaternary Paleo-Sealevel Map of Canada (1:1M scale) will be most useful to scientists and engineers working in areas that are, or have been, directly affected by sealevel fluctuations. Environmental interpretations can be drawn from the map data. The Beaufort Sea Atlas is appearing at an opportune time, which is in anticipation of the next major round of offshore drilling and subsequent product in the Beaufort Sea. Two folios have already been published and a third is in press. The work will be of direct assistance to developers of oil and gas in the region, as well as to consultants and agencies working on environmental problems.

An abstract of Subdivision activities was published in the Newsletter of the Canadian Committee on Climatic Fluctuations and Man.

PALEOECOLOGY SECTION

Staff in this Section identify plant remains, peat, mosses, spores and pollen in sediments as an aid to interpreting the ancient environment. Commonly fossil insects are also identified for this purpose. Selected material is subjected to ^{14}C dating methods in an effort to determine the age of the deposits. Considerable service work to support the regional mapping projects is also carried out.

Important concepts are being established on the effect of large proglacial lakes and glacial melt-water discharge on the cooling climate of central and eastern North America during the Younger Dryas period of 10 000 to 11 500 years ago and also of the period between 8000 and 9500 years before the present. In eastern Canada these cooling periods are continuing to be documented by means of pollen biostratigraphy; this latter study forms the framework for late-glacial chronology because the earth materials obtained from the area are so well dated. All this work will lead to a fuller understanding of climate changes in North America during the past 12 000 years.

In arctic regions, such as the Yukon and adjacent Northwest Territories, glacial and climatic events are being documented with the aid of so- called tephra chronology and paleontology (in this case, fossil insects). The distribution of modern vegetation and its relationship to climatology is being used as a model for interpreting past environments during the Quaternary period in the Queen Elizabeth Islands, and Banks and Victoria islands. Elsewhere in the Arctic islands, vascular plants and moss assemblages are being studied in peat occurrences in the Beaufort Formation on Prince Patrick Island with a view toward interpreting the environment when these sedimentary beds were deposited. Similarly, several Holocene peat sections were collected from an area of active erosion in central Victoria Island, and are being dated by means of ^{14}C methods. A peat stratigraphy is being established in order to examine paleoenvironments through time. An interesting study on diatoms and other minute algae known as chrysophytes has led to a positive means of distinguishing marine ice from fresh-water ice. This, in turn, leads to an indication of the environment at the time these plants lived.

Both field and laboratory work has led to the publication of 17 abstracts of formal talks, 2 GSC papers in press, and 1 map in press. In addition, 77 service reports were submitted, dealing with identification of spores and pollen (palynology), wood, seeds and leaves (plant macrofossils), and fossil insects (arthropods).

GLACIOLOGY SECTION

Field work in this Section involves the study of snow and glacial ice in the Canadian Arctic islands. Snow pits are examined for plant aerosols, such as pollen, and ice (obtained in drill cores) is analyzed for certain elements and gases commonly transported in the atmosphere. An extensive laboratory program and an

intensive computer search for meteorological data are used to help complement the field studies.

Examination of cores from the ice caps of the Canadian Arctic Archipelago, Greenland, and Antarctica has led to three tentative conclusions: (1) massive melting of Greenland ice about 100 000 years ago, which either removed all the ice or reduced it to much smaller dimensions in central and northern parts; (2) dirt at the bottom of the cores is not due to 'freeze on'; erosion by this ice sheet is therefore very small; and (3) melting of the Laurentide ice-sheet and the flow of negative isotope water into the ocean has disturbed ice-core records for the period that occurred 18 000-8000 years ago. A new surface-to-bed core was obtained, which yielded information that assisted in reaching the first two conclusions just mentioned. A significant revelation appeared after painstaking palynological analyses were made of snow pits at the drill-core site; that is, strong seasonal fluctuations in pollen concentrations in the top few metres of the snow/firn from these pits in the Canadian Arctic islands were detected. These findings will be of value in interpreting pollen concentrations in ice cores. In a companion study, changing concentrations of pollen, etc. in the snow and cores have been related to past and present synoptic climatological patterns. These studies thus allow the investigation of atmospheric transport mechanisms to be undertaken.

Scientists from this Section have contributed 6 published abstracts of formal talks, and 3 papers to outside journals.

SEDIMENTOLOGY RESEARCH GROUP

W.W. Shilts, Head

The Sedimentology Research Group carried out activities related to glacial and related sedimentation including bedforms beneath ice sheets. Activities were largely related to applications of sedimentological research to practical problems in mineral exploration, environmental geochemistry, and seismic hazard research. Data processing research concentrated on graphics to illustrate research results was also carried out in this unit.

Among the various activities and results from this group, the following are most noteworthy:

(1) A map of the bedforms on the Canadian Shield part of the Keewatin Ice Sheet was completed at a scale of 1:1 000 000 and, with text, is being drafted for printing in 1988. The area covered by this map is approximately 1,160,000 square kilometres. The map and its features were combined with similar maps from other parts of the Shield to provide a chapter on "Glacial Geomorphology of the Canadian Shield" in the GSC-DNAG series, "Geomorphology of North America".

(2) Major programming efforts were directed toward systematizing a Divisional database to be applied to compositional and other quantitative information on a Canada-wide basis. Graphics to present information from this database were refined, including adaptation of Applicon colour plotter maps to drift geochemical information for rapid open file release. Graphics for plotting directional information such as striations were developed. A significant development in transforming accoustical high resolution seismic information from lakes and other waterbodies as three-dimensional, colour, fence-type plots was initiated in co-operation and under contract to the Computer Science Centre.

(3) Sonar surveys of lakes in Quebec and on Vancouver Island were carried out to determine if any disturbed sediments indicative of historic or prehistoric earthquake damage could be found. In Lac Temiscouata, located in a supposedly seismically benign transverse valley through the Appalachians, signs of major earthquake disturbances were found, possibly indicating disruptions by several events. As part of the New Brunswick MDA, major early postglacial rockslides were found beside the Madawaska River in the same valley. A report on these findings is being made at the annual meeting of Geological Association of Canada in May 1988. Evidence of slumping related to strong historical earthquakes was found in lakes on Vancouver Island as well as some unexpected sedimentological features. In one lake, a clearly defined reflector in modern sediment is thought to be a tephra layer, present throughout the basin; in another, a series of recessional moraines and subaqueous fans were clearly recorded.

(4) A major A-base-funded effort was made to assess the relationship of surficial geology to maple decline in the Thetford Mines area of Quebec. A report on the research, carried out under contract to University of Montreal, has been prepared, but not submitted. Preliminary reports, forwarded to the Minister and to Canadian Climate Research Centre, indicate, on the basis of interviews with farmers, that severe climate fluctuations in winter/spring of 1981, caused much of the present decline, a conclusion reached independently by Dr. Auclair of the Canadian Climate Centre in a recently published paper.

(5) Mapping of a critical 1:50 000 sheet on Chaudière River, in the Beauceville-St. Joseph area south of Quebec City was carried out and will form the basis for an M.Sc. thesis. The research showed that a complex late-glacial sequence of ice movements is recorded in the map area. It is important to interpret the history of these glacial flows because of important mineral exploration activity in this gold- and base metal-rich region.

(6) MDA projects carried out under this Unit are reported on under Quaternary Geology Subdivision.

Personnel of the Sedimentology Research Group answered approximately 80 requests for information and guidance on projects drawing on work carried out by GSC. These requests were mostly from the private sector and concerned mostly work in mineral exploration. Many inquiries about environmental problems (acid rain, neotectonics, forest decline) and about technical aspects of our work (rotasonic drilling, sample processing, sonar surveys, bathymetric and other data processing and graphics) were also answered.

SEDIMENTARY AND MARINE GEOSCIENCE BRANCH

C.R. Barnes

ATLANTIC GEOSCIENCE CENTRE

M. J. KEEN

The Division's objectives are to ensure that geological information and expertise are available for the offshore regions of Atlantic and Arctic Canada, the sedimentary basins of the Appalachian region, and for the ocean basins in general, when necessary. The knowledge and information is directed to national needs of the following sorts: identification of the base of resources available; the formulation of mineral and energy policy; making exploration for Canadian resources easier; and enhancement of the nation's intellectual base in the earth sciences.

We meet these objectives by: undertaking geological, geophysical and geochemical research, including surveys, regional interpretation and synthesis; establishment of appropriate national and international standards for geological chronology, correlation, reference materials and surveys; identification of the characteristics and probable locations of occurrences of coal, oil and gas resources and estimates of their abundance; identification of the characteristics of the terrain offshore for its safe and proper use; development of methods and technologies to improve the effectiveness of marine geoscience surveys, discovery of resources and the determination of terrain properties; the dissemination of information.

The Division is organized into five Subdivisions: Administration, Program Support, Environmental Marine Geology, Eastern Petroleum Geology and Regional Reconnaissance. The following accounts relate the highlights of the work of the Division during fiscal year 1987-88.

ADMINISTRATION

The objectives of the Administration Subdivision are to provide efficient and effective financial, personnel and general administrative guidance and support to the Atlantic Geoscience Centre. The Subdivision consists of the Director's Office, Administrative Officer's office, Personnel Office and Finance Office with each section supplying the general administrative support necessary to ensure a smooth operation.

ENVIRONMENTAL MARINE GEOLOGY

The Subdivision is responsible for the surficial marine geology of eastern and northern Canada. Field surveys provide a knowledge base of the distribution and characteristics of surficial sediments and shallow bedrock offshore and in the coastal zone, and an understanding of the processes responsible for the deposition and reworking of coastal and marine sediments. Results from this work are published both as maps and papers. The work allows the subdivision to provide advice for the rational management of marine areas and the identification and development of natural resources.

The core program of the subdivision is funded by the Geological Survey of Canada out of the regular A-base budget. In addition, the subdivision receives funds under several special programs during the year: Task 6.3 Energy R&D Task of the Office of Energy Research and Development (OERD), the Frontier Geoscience Program (FGP), and the Northern Oil and Gas Action Plan (NOGAP), in order to carry out or accelerate specific research programs.

Core Program (funded out of A-Base)

Coastal Projects

Work continued on shoreface and inner shelf sediment mobility on the Eastern Shore of Nova Scotia, particularly the behaviour of gravels and bedforms; on an evolutionary model for gravel barriers, headlands and lagoons; and on sand supply in the southern Gulf of St. Lawrence. This latter was presented at the Coastal Sediments '87 meeting. Further field studies were carried out on Holocene sea level change in N.E. Newfoundland and a summary paper on this topic was completed.

Aerial video coverage was obtained of the south coast of the Bay of Fundy. Selected cliff and beach recession sites in Nova Scotia were monitored.

The interactive mapping procedures were completed for the Coastal Information System and a working version of the Atlas of the Avalon Peninsula was produced.

An Open File was released on coastal surveys within the Queen Elizabeth Islands, and an oral presentation made on the ice dominated shores of Lougheed Island.

Coastal Inlets and Deltas

A cruise to acquire seismic data and cores from the North Shore deltas of the Gulf of St. Lawrence and Chaleur Bay was successfully completed.

A vibrocoring survey was carried out on Iterbilung Delta in preparation for Arctic Delta Failure Experiment (ADFEX). The survey was inconclusive as to whether permafrost was likely to inhibit slope failure. Further studies will be required.

A manuscript on the numeric delta progradation model was completed.

The 19th century paleodischarge record in Saguenay Fiord was presented at the INQUA Congress, and an evaluation of the 20th century pollution history has been completed.

The configuration of the floc camera was redesigned and successfully tested in the St. Lawrence Estuary.

Litho- and bio- stratigraphic analysis of SAFE cores was completed, and manuscripts on basin infilling and oceanic controls of sediment distribution in glacier-influenced fiords were completed.

Two further manuscripts on the sediments of Chignecto Bay were completed. Turbid plumes and boils greatly complicate the dynamics of suspended sediment distribution in the Bay.

Geochemistry

Analysis of Nares Abyssal Plain samples were completed. The volume on the ESOPE expedition to the Nares is in press, and the final recommendations of the Seabed Working Group were completed. The project has shown that the concept of nuclear waste disposal in abyssal plain sediments is feasible, but advection along faults poses problems. The project demonstrated the important role of pH in controlling early diagenetic reactions which affect both the global cycling of elements and the development of early diagenetic minerals.

Regional Geology: Southeastern Canada

A short cruise was completed off eastern Cape Breton to map and sample the distribution of nearshore sediments. Provision of potentially Ti-rich samples to Tioxide for their evaluation has continued.

A joint USGS/GSC program acquired GLORIA data over 75,000 km^2 of the southwest Scotian Rise. Processing of the data is largely complete. Preliminary interpretation shows that the rise is dominated by down-slope movement of glacial derived detritus in the Pleistocene.

Long stratigraphic cores were obtained with the Long Coring Facility (LCF) from the Fogo Seamounts, and groundtruth data was obtained from the area of the French SAR survey around the Titanic.

Regional Geology: Eastern Arctic and Subarctic

A transect of cores across the Svalbard sector of the Arctic Ocean were collected from RV Polarstern for analysis of dinocyst stratigraphy. Acquisition of a suite of type stratigraphic cores using the LCF was obtained from CSS Hudson in Baffin Bay, Davis Strait, Hudson Strait and the Labrador Shelf. This was the first operational use of the LCF, designed and built at University of Rhode Island with some financial support from OERD.

Frontier Geoscience Program

Four activities within the subdivision were funded by the Frontier Geoscience Program. They include: (1) east coast offshore mapping, lithological and biostratigraphic investigations; (2) initiation of a physical sediment properties and geotechnics project; (3) sea floor mapping and sampling of the Arctic Basin from an Ice Island platform; and (4) participation in the Ocean Drilling Program (ODP) in which the subdivision has played a significant role.

Acceleration of offshore mapping program

As part of a bedrock program in Hudson Bay, significant additional high resolution seismic and sidescan data were acquired, and several long piston cores were collected to characterize the seismic units and establish a stratigraphic mapping framework.

In the Sable Island area, a set of 6 maps (data control, bedform zonation, grainsize distribution, thickness of holocene sediments, sample locations and sidescan interpretation) for five 1:250,000 map sheets were completed as part of a new surficial geology map series.

Physical properties and geotechnics project

The physical properties and geotechnics research program, sponsored by FGP, has four major components: (1) basic research; (2) mapping; (3) geological processes research; and (4) technological developments. The ongoing basic research is focussed on the consolidation or stress history of sediments with respect to the geological history; the strength and stress-strain behaviour of sediments under geological and man-made loading conditions; and on the correlation of sediment physical and acoustic properties.

Borehole samples were obtained at the Como and Panuke sites on the Scotian Shelf through a cooperative program with Petro-Canada. At Panuke, AGC extended the boreholes to 60 metres to provide ground truthing for regional seismic stratigraphy. An AGC borehole program was completed on the Grand Banks. This program provided the first opportunity to sample stratigraphic units that had previously only been defined on the basis of seismic data. Drilling results identified one basal till unit and the measurement of physical properties of the samples obtained now allow us to say how compressible material is and begin to specify requirements for future site investigation work necessary for establishing a bottom mounted gravity based structure for hydrocarbon production. An extension of the program requested by Public Works Canada to acquire borehole data in Northumberland Strait provided an opportunity for additional sample and in situ geotechnical measurements in an area of peripheral but important interest to the program.

A physical properties laboratory is now fully operational at AGC. It enables researchers to: (1) measure stress history of marine sediments in order to quantify models of their geological, and in particular glacial, history; (2) carry out studies of acoustic and physical properties correlation essential for the quantitative interpretation of seismic and acoustic information; and (3) study sediment deformation under a variety of loading conditions.

Ice Island Arctic Basin Project

Seafloor sampling from the Ice Island was extended through the use of a program of helicopter supported mobile sampling along transects across the margin north of the Island position. The work has shown that five Late Quaternary sediment units are widely correlatable over depths of 120-300 m on the inner shelf.

Ocean Drilling Program

G. Vilks participated on Leg 115, Indian Ocean-Seychelles Bank. Carbonate turbidites were recovered in unexpected abundance, showing evidence for transport over a long distance across the abyssal plains. Studies at AGC are focussing on the preservation of organic matter in the turbidites. R. Cranston participated on Leg 115, Eastern Antarctica to investigate the facilities of the vessel for modern geochemical studies of pore waters. This participation will lead to proposed changes for on board sampling and analysis.

Energy Research & Development Program

The Energy R&D Program involves work in both the Beaufort Sea and East Coast Offshore under the Offshore Geotechnics Program Task 6.3.

Beaufort Sea

Revisions of the 100 meter to 1000 meter seismostratigraphy and correlation with boreholes was continued. Determination of physical properties in Angasak boreholes was completed as a cooperative project with Esso Resources. Current measurements in the vicinity of the Amauligak drill site were obtained in cooperation with Gulf Canada to provide information related to potential berm erosion problems.

A cooperative research project involving industry, university and government groups was initiated to investigate the initiation of liquefaction in the sand core of the Molikpaq hybrid drilling platform under sustained ice loading. Gulf Canada Resources has released all relevant data concerning ice loads, core properties and liquefaction response for use in the study.

East Coast Geotechnics Program

Scientific results of the Dynamic Iceberg Grounding Experiment (DIGS), Ice scour frequency on the Grand Banks and infilling of seabed depressions were released. A method for calculating nearsurface sediment seismic velocities from Huntec DTS data was developed which will be used in the studies of the correlation of acoustic and physical properties of sediments. A compilation of regional shallow seismic reflection data, including information from industry site surveys, has been incorporated in a digital data base and will be updated as part of a new seismic acquisition program in 1988. A numeric sediment transport model for Sable Bank has been calibrated and stability of ripple marks under wave and current action assessed.

Northern Oil & Gas Action Plan (NOGAP)

NOGAP funding for 1987 was 40% lower than the original approved budget and with the potential for renewal in 1988 being uncertain, the emphasis was on obtaining as complete a data set of field observations as possible.

Beaufort Coastal Zone Geotechnics

A videotape survey of the ice breakup processes along the Beaufort coast was completed under contract. It documented the stages of breakup and identified scour and ridge features, as well as strudel scour resulting from rivers overflowing the ice.

A sedimentological study of the MacKenzie Delta distributory mouth environment looked at the processes of sedimentation and build out of the modern delta.

Seismic, sidesacan and vibrocoring were completed off the MacKenzie Delta and a cooperative program with the USGS on RV Karluk collected data relating to coastal erosion, nearshore sand deposition and ice scouring the Tuktoyaktuk Peninsula.

A unique data set of wave and current measurements for the study of nearshore sediment transport on the Beaufort Sea coast was obtained off Tibjak Point.

Arctic Island Channel Geotechnics

The use of small seismic systems through open water leads in the sea ice provided regional information on the seabed sediments and bedrock east of Lougheed and west and south of King Christian Islands. Results of this and the previous year's work show that seabed sediments consist of glacial drift kept by up to 5 m of postglacial muds.

Regional data was also obtained in the southern and eastern Norwegian Bay during a collaborative investigation with the Canadian Hydrographic Service. The data shows sediments up to 35 meters thick and scouring of the sea floor by bottom currents in and northwest of Cardigan Strait.

Provision of Advice

Provision of scientific and technical advice continues to be a major part of the work of the subdivision, as is clearly reflected in the industry-supported special programs. The subdivision has been involved in preliminary environmental assessments for hydrocarbon exploration on Georges Bank and the Northumberland Strait causeway/bridge crossing.

There has been increased demand for information on the offshore for advice on: a possible power cable to Maine from Nova Scotia; telecommunication cables across the Bay of Fundy and Scotian Shelf; and review of ocean dumping applications for the Atlantic region.

In the coastal zone, there is increased demand for information on nearshore sediment because of interest in placer gold, aggregates, silica and titanium placer. Advice on shoreline stability and shore protection measures are provided to National Parks to assist in preserving national monuments and facilities, and the planning of new parks.

Advice is also provided to local shorefront property owners who are suffering from increased shore erosion.

EASTERN PETROLEUM GEOLOGY

The subdivision is responsible for the subsurface geology of the sedimentary basins of eastern Canada and contiguous areas. The objectives are: to increase our knowledge of subsurface geology of the sedimentary basins of offshore eastern Canada and contiguous areas, to interpret the hydrocarbon potential of these basins, and to undertake periodic appraisals of such resources. Studies of the upper Paleozoic basins of the Atlantic Provinces and their coal and hydrocarbon resources are also undertaken.

Offshore eastern Canada encompasses an area stretching from 41°N to 76oN. Specific areas include: Baffin Bay, Davis Strait, Hudson Bay, Hudson Strait, Labrador Shelf, Northeast Newfoundland, Grand Banks, Gulf of St. Lawrence, Scotian Shelf, and the Bay of Fundy. Contiguous areas studied by subdivision scientists include the North Atlantic, Labrador Sea, western Europe, the

U.S. continental margin, as well as onshore sedimentary basins of the Atlantic Provinces.

Twenty-five scientific projects are carried out in one of the three main categories within the subdivision. Basin analysis and petroleum geology utilize the disciplines of petroleum geology, geophysics, lithostratigraphy, geochemistry, sedimentology and biostratigraphy. Resource appraisal draws heavily on seismic stratigraphy and geochemical information. Biostratigraphy includes palynology and micropaleontology. Data bases span these major disciplines and provide a link between them.

The resource appraisal program is part of EMR's inter-branch assessment. It has been carried out in collaboration with the federal regulatory agency, Canada Oil and Gas Lands Administration (COGLA), staff of the Petroleum Resource Appraisal Secretariat (PRAS) at ISPG in Calgary and the Canada-Newfoundland Offshore Petroleum Board (CNOPB) in St. John's.

A-BASE

Petroleum Resource Appraisals

Work continued on the Jeanne d'Arc Basin appraisal with a final meeting to establish resources scheduled for summer of 1988. Reports on the regional geology and the hydrocarbon resource potential for the St. Pierre and Miquelon dispute area were completed and sent to External Affairs. This work completes the evaluation of the eastern part of the Scotian Basin and illustrates some unique features by comparison with areas elsewhere.

Information was provided for the Lancaster Sound resource assessment and comments provided on the first draft of the joint report from COGLA and Parks Canada.

Data Base Development

Work continued on the development of Palylit, Lithfile, Biostrat, Wellsys and other well data files. These data bases provide the primary information for compilation of east coast offshore basin geology and will be converted to the new Oracle data base in 1988.

Quantitative Stratigraphic Methods

Gradstein, AGC and Agterberg, MRD have continued to promote the application of quantitative stratigraphic methods to geohistory basin models through a series of lecture courses worldwide. These courses are based on the book by Gradstein, Agterberg, Brower and Schwarzacher (with a Chinese edition appearing in 1988) and computer programs available through the GSC. The techniques have been applied in our work in the basins off eastern Canada and a consortium of Canadian oil companies has applied the work to detailed correlation in the Hibernia field.

Frontier Geoscience Program

A major output for the Frontier Geoscience Program will consist of a series of basin atlases of the east coast of Canada. Compilation of maps and interpreted sections for the Labrador Shelf atlas was completed in 1987 and will be published by the end of 1988. The atlas is a significant synthesis of present knowledge of the Labrador Sea area and will incorporate some 60 sheets of maps, charts, cross sections and text. The project has benefited tremendously from the participation of Petro Canada and BP Canada staff and the release of information held in these companies' files. Contractors involved in the biostratigraphic and lithostratigraphic analyses of wells on the Labrador Shelf participated with AGC scientists in producing a series of paleoenvironment maps through the integration of data from the various disciplines.

The success with contracted biostratigraphic analyses for wells on the Labrador Shelf has resulted in another 25 wells being completed for paleontological and palynological analysis on the Scotian and Grand Banks. This work has provided an excellent framework for reliable biostratigraphical zonation and regional stratigraphic correlations of the areas. A composite zonation of 87 foraminifera and ostracod zones has been used to prepare biozonation charts for the area from Georges Bank to Northeastern Grand Banks and to identify corresponding ages and upper and lower boundaries.

Calibration of seismic reflection sequence and facies analysis for the upper Jurassic and Cretaceous sequences in the Venture Field area has been completed as a first step in mapping the distribution of facies and rock type for regional analysis.

Joint geochemical studies with staff of ISPG have identified the major source rock for the Jeanne d'Arc Basin as the kimmeridgian aged egret member of the rankin formation, but have also shown that some oil pools in one area of the basin have a significant contribution from a different source. Analysis of oils recovered from the H-73 well on the southern Grand Banks indicates a source rock of very different characteristics. Combined study of the geochemistry and lithostratigraphy have led to a better definition of the Jurassic stratigraphy of the Jeanne d'Arc Basin.

Joint program with SOQUIP provided a synthesis of industry data in the Gulf of St. Lawrence. This was an excellent example of a cooperative project with industry to ensure that work undertaken under FGP builds on the present knowledge and expertise in the frontier area.

Compilations of in situ stress for offshore eastern Canada has continued with John Adams of Geophysics Division. Work on Labrador data is complete and will be incorporated in the basin atlas. The east coast information forms part of a national compilation of stress for North America.

Processing of high resolution multichannel seismic data acquired in Hudson Bay during 1986 was completed under contract and has generated significant interest with several petroleum companies. Additional single channel seismic data was acquired as part of a bedrock sampling program in 1987 and this data set has provided the first definition of a significant sedimentary basin in Evans Strait.

Energy Research and Development Program

Overpressures in the Venture Field

The overpressure region, common in the Sable Subbasin and at Hibernia, is potentially an important hydrocarbon "play" as well as a constraint in field development. Modelling of the Venture field has shown that several factors affect the phenomena depending on the physical conditions at the time of their deposition. To date, a one-dimensional, single phase analytic model has been developed which includes the effects of sedimentation, porosity, compressibility, non zero temperature gradient, temperature dependent hydrocarbon generation and fluid viscosity and variable sedimentation rates. Initial results have been written up and a joint project with Institut Francais du Petrole to expand the model to two dimensions has been initiated.

REGIONAL RECONNAISSANCE

The primary objective of the subdivision is to study the deep geology and geophysical properties of the continental margins and adjacent offshore regions in order to understand the processes controlling their development and evolution. While effort is focussed on the contemporary margins, this has inevitably led to studies of the adjacent continental and oceanic regions, and to interests in analogous features globally. To accomplish this, subdivision scientists carry out detailed studies in key areas, using seismic and potential field data collected from ships, aircraft, satellites, and Arctic ice camps. Findings are integrated with the results of work done elsewhere or derived from complementary data types. Geodynamic modelling to test conceptual models is a key element of our program. Cooperative effort is an important aspect of the work, involving ongoing contractual and collaboration with other federal government agencies, universities, industry and foreign institutions.

Primary funding for the subdivision's program is provided by the Frontier Geoscience Program as part of its objective to develop an understanding of the origins and tectonic controls of the east coast sedimentary basins.

Deep Seismic Reflection Studies

800 km of deep seismic reflection (20 second, two-way travel time) was obtained along the Grand Banks margin, Jeanne d'Arc Basin and Orphan Basin. These data provided tie lines to earlier deep reflection data acquired under the Frontier Geoscience Program, industry seismic data available in the region, and completed the deep reflection studies of the Grand Banks sedimentary basin. Experimental reprocessing of several of the Grand Banks lines was carried out by two companies offering special software for data reprocessing and the Centre for Earth Resources Research at Memorial University in an attempt to clarify deep structures in the sedimentary basins and across the margin. Results from one company (Western) are particularly good, clearly showing deep structure, including fracture zones across the Transform margin. A Sierra geophysics software package has been used to assist in the interpretation of deep seismic lines and to model subsurface structures. Deep reflection obtained in the Gulf of St. Lawrence in 1986 has been interpreted and the results submitted for publication. An important component of this work has been the integration of results with the basin studies carried out jointly with SOQUIP.

Deep Seismic Refraction Studies

Deep crustal refraction studies using arrays of ocean bottom seismometers were completed on the Grand Banks and seaward of Flemish Cap. The experiments were conducted at a dense distribution of shots along pre-existing deep reflection lines to provide velocity control at depth for the reprocessing of the reflection data, map variations in Moho and deep crustal structure, and provide additional information to clarify the ocean-continent transition along the eastern margin of the Banks.

Results from the 1985 Ice Island refraction experiment have been interpreted in the context of velocity data from wells north of the Sverdrup Rim and velocity from early refraction experiments on the continental margin. The similarity in the velocity depth profiles from the various data sets suggests that it is possible to develop seismic stratigraphy for the margin north of Axel Heiberg Island.

Potential Field Studies

Two major aeromagnetic surveys were carried out over the eastern Grand Banks and margin. A contracted high resolution survey over the central Grand Banks completed the aeromagnetic coverage of the major sedimentary basins. A regional survey over the deep waters of the Newfoundland Basin, undertaken in cooperation with the U.S. Naval Research Laboratory, provided good coverage across the margin and the adjacent ocean basin. The interpretation of the data has shown strong similarities in the continental and oceanic tectonic fabric, suggesting direct linkage between the formation of the sedimentary basins and the pattern of opening of the North Atlantic.

Potential field maps in crustal transects of the Labrador Sea basin atlas have been completed and a series of maps showing the sea floor history of the Labrador Sea initiated.

The final draft of the North Atlantic Geophysical Atlas, undertaken in cooperation with the German Hydrographic Office and other international agencies, has been completed.

The subdivision also continues to contribute to NESS magnetic and gravity maps in marine areas.

Cooperative investigations of magnetic anomalies with Brock University have provided new information on the magnetization of the oceanic crust.

Geodynamic Modelling

Efforts in geodynamic modelling concentrated on developing and implementing a finite element modelling package to provide a unique facility for studying geological problems involving large strains such as the geodynamic evolution of extensional systems and orogenic belts. The new facility will be applied to further studies of the Jeanne d'Arc Basin.

Investigations of the thermal effects at a transform margin using observations from the southern margin of the Grand Banks provide values on the thermal and uplift history of the continent adjacent to the transform margin. The results show significant uplift which persists up to 60 km inland

and raises questions concerning the origin of unconformities on the Grand Banks.

PROGRAM SUPPORT

The mandate of Program Support Subdivision is to provide effective central support in electronic and mechanical engineering, data management, information systems, planning, coordination, development and maintenance, field logistics and field equipment maintenance.

To meet this mandate, the subdivision is divided into three sections as follows.

The Technical Services Section is responsible for providing, operating and maintaining all geophysical equipment, seismic refraction and reflection instruments, sidescan sonar survey systems, and magnetic and gravity instruments as well as marine geological sampling equipment such as piston, gravity, rock and vibrocorers; Shipek, Van Veen and Echman grab samplers and rock dredges. This section also provides the Division's primary logistic support for all field projects and equipment by providing, outfitting and maintaining field vehicles, ATV's, trailers, launches, boats and freight and laboratory containers. In recent years, staff in this section have taken on responsibility for the management of significant contracts for maintenance and enhancement of systems, have cooperated with engineers and scientific staff in the improvement of systems and equipment, and have adjusted to the increasing use of computers as integral components in many systems.

The Instrument Development Section designs, develops and tests electronic and mechanical equipment to enhance existing systems or to meet the requirements for new instrumentation made necessary by new scientific objectives of the Division. This group works in close cooperation with scientific investigators during planning, design, development and implementation of new systems.

The Data Management Section is responsible for the safe archiving and cataloguing of data and samples and provision of reasonable accessability; the administration of data release and provision of better methods of data release; the development and maintenance of AGC institutional software and provision of assistance in software development; the management of institutional information systems and advising and implementing policy on AGC computer usage.

Highlights

Subdivision staff supported 43 projects in the 1987/88 field season. These projects involved field and ship time on the east coast, in the Arctic, and on the west coast of Canada. Of these projects, eight involved universities and 6 were in support of other Canadian government agencies. It required approximately 830 person days to support these projects.

Ice Island Project

AGC staff made to trips to the Ice Island this field season. The first trip was to open the camp and to complete a helicopter survey of the shelf area. Also, a new piston coring system was successfully tested during this phase of the season. More piston coring and grab sampling was done during the summer phase.

Long Coring Facility

The Long Coring Facility (LCF) is a large piston coring system developed by the University of Rhode Island with support of the Atlantic Geoscience Centre over the past three years. The LCF, installed on CSS Hudson last fiscal year (March 1987) was used this year to obtain longer and larger diameter piston core samples than had previously been possible.

Floc Camera

Suspended particulate matter in the ocean tends to floculate to produce particles (called floc) which are large enough to see. Floc have been observed through the portholes of manned submersibles, but are difficult to study because sampling techniques tend to destroy them. To assist submersible observations, a floc camera assembly has been developed at the Atlantic Geoscience Centre to produce quantitative data on floc. The assembly consists of a collimated Xenon flash, three cameras, a depth sensor and a computer to control the components in a programmable manner. The position coordinates and particle dimensions are later determined on the Lietz TAS image analysis system which is linked to the mainframe computer. By lowering the camera assembly slowly through the water column, profiles of floc abundance, size distribution and shape characteristics can be measured. By placing the system motionless on the sea floor, we can take time lapse stereo photographs of floc and measure in situ settling rates. These methods are viable methods of obtaining quantitative data on in-situ properties of suspended particulate matter.

Curation

During the past year, the technologies associated with data acquisition and communication have greatly assisted the efforts of the Atlantic Geoscience Centre Curation Group with their continued cataloguing and storage of geophysical records and samples. Associated site specific record and sample data continues to be maintained on the RECINV and Sample Information (SID) data bases. Improved data management for conversion from System 2000 have also been investigated for the interactive relational data bases in order to provide the best possible means of access to enter, edit, and retrieve raw data. In 1987, 25 sampling cruises and 5 field programs collected samples from more than 550 stations, with an estimated recovery of more than 2000 metres of soft sediments and drill cores, together with approximately 50,000 line kilometers of seismic reflection, Huntec, sidescan sonar and bathymetric underway records. Cruise station information has also been submitted to the National Geophysical Data Centre in Boulder, Colorado, USA for inclusion with the Worldwide Marine Geological Data Base.

Microfilming of Geophysical Records

The majority of underway geophysical data is presently being prepared for conversion to continuous 35 mm microfilm and will be prepared for Geological Survey of Canada Open File Reports during 1988 and

1989. More than 150,000 lineal meters of underway geophysical records presently curated by the Program Support Subdivision have been converted to microfilm under contract, utilizing a TAMERAN 6000 flow camera. Records from 1972 to 1987 have been inspected for quality control and data for more than 250 cruises has been captured on film for permanent retention. Similar investigations are ongoing for the conversion of the Atlantic Geoscience Centre's 30,000+ magnetic tape holdings which would permit potential tape recycling and an adequate medium for future retention is also sought for reduction in storage space.

Data Inventory

A project (GSC 830053) to initiate an inventory of the Atlantic Geoscience Centre holdings by improving methodology for record/sample acquisition, and reporting of annual field acquisitions, has been conducted to permit safe archiving and cataloguing of the Centre's data collections and holdings. This has resulted in annual indices, data bases of record/-sample holdings which are continuously updated and maintained by the management systems now in place. Routine inquiries for access to data or for data reports from ocean-related industries, educational centres and other federal/provincial government departments and agencies in the Atlantic region are processed daily in an effort to disseminate this vast volume of geomarine data housed at the Atlantic Geoscience Centre.

CORDILLERAN AND PACIFIC GEOSCIENCE DIVISION

D.J. Tempelman-Kluit

The Cordilleran and Pacific Margin Division is responsible for geological and geophysical studies in most of the Canadian Cordillera, the continental margin, and the adjacent deep ocean. Our mandate is to increase the knowledge of the composition, age and origin of the earth's crust in the region, so as to permit accurate assessments of the mineral and hydrocarbon potential and guide mineral and hydrocarbon exploration. It will also help identify and predict geological hazards on land and on the seafloor and will provide the knowledge needed for planning and orderly development of land use.

The Division operates from offices in two locations - Vancouver and Sidney, B.C. It incorporates personnel who were part of the Geological Survey of Canada and the Earth Physics Branch before April 1986. Amalgamation of the two groups is now complete and we are operating as one Division with three sections - one concerned with mainland geology and geophysics, a second with the geology and geophysics of the offshore and a third focussed on neotectonics and seismicity.

The Cordilleran and Pacific Geoscience Division has 70 full-time employees, 29 at Vancouver and 41 at Sidney. The Vancouver office includes 16 scientists and 13 staff in administration, sales library and technical support services. In addition one scientist from the Mineral Resources Division and two from Terrain Sciences Division are stationed at Vancouver. At Sidney the staff consists of 17 scientists and 24 support and administrative staff.

Efforts in mainland geology involve a broad spectrum of studies aimed at the bedrock geology of the region that hosts most of Canada's western mineral deposits. This work, which involves mapping the rock unit distribution and detailed studies of the stratigraphy, age, biostratigraphy, petrology, metamorphism and structure, is done in Vancouver. The geophysics of this region - its gravity and magnetic fields, heat flow and paleomagnetism - is done by scientists based in Sidney. The aim is to improve the geoscience data base, and to extrapolate surface geology to depth, for better mineral and hydrocarbon assessments and for effective exploration.

The geology of potential hydrocarbon basins on the Pacific Continental shelf and that of the surficial sediments of the Pacific Continental Shelf and deep seafloor are studied by our scientists based in Sidney. Efforts in the hydrocarbon basins are concentrated on the stratigraphy, biostratigraphy, thermal history, and source and reservoir rock characteristics of the basinal strata - the data permits assessment of the hydrocarbon potential. Study of the surficial sediments aims to determine the resources and to identify hazards to development in the coastal zone.

Our work in neotectonics and seismicity involves monitoring west coast earthquakes in Canada's most active region. Hence we operate the western Canada telemetred seismic net from our Sidney office to determine the magnitude, locus, frequency, and origin of earthquakes. To determine past seismicity we study the surficial sediments on the west coast. The ultimate aim of these efforts is prediction of major earthquakes.

The Division maintains an excellent research library which is open to the public and operates a Sales Office where Departmental publications and maps are available.

Highlights

Queen Charlotte Islands Frontier Geoscience Project

Under the Frontier Geoscience Program, GSC began new work to assess the hydrocarbon potential of the Queen Charlotte Basin. This, the division's largest single effort, is designed to address the FGP geological objectives equally and to build the team approach to geological problem-solving in the division. It was led by Bob Thompson and involved 42 scientists, 22 from this division (13 from the Pacific Subdivision and 9 from Cordilleran Subdivision), 7 from the Institute of Sedimentary and Petroleum Geology, 5 from the University of British Columbia, 2 from the University of Ottawa and Memorial University and several contractors.

The project includes land and marine geological and geophysical studies aimed at improving the geological knowledge base. It will allow better hydrocarbon assessment, more effective exploration when the West Coast Moratorium is lifted and better planning for development.

Specific data are required on a) source rock properties and stratigraphy, b) reservoir properties, c) source and reservoir biostratigraphy, d) source, reservoir and seep geochemistry, e) basin structure and evolution especially thermal evolution and f) seismic risk and seabed hazards to development. Work done includes on land geological mapping and stratigraphic and structural analyses, organic geochemistry, paleontology and biostratigraphy, heat flow, sea bed hazard analysis, earthquake monitoring, and potential field studies. Acquisition and interpretation of reflection and refraction seismic data are planned. A complete set of the results of last summer's field work was published in Current Research and released as an offprint by GID - this was extremely well received by user groups.

The Rennell Sound fault system of Sutherland Brown is more properly regarded as a fold belt. Northeast directed reverse faults which involve the Upper Cretaceous Honna Formation were recognized. (Thompson)

Large scale strike-slip along the Sandspit fault is unlikely; instead the fault is probably an east-side-down ('down-to-basin') normal fault on which the Tertiary Queen Charlotte basin grew. (Thompson)

An important block-faulting event preceded the deposition of Haida Formation (Albian).

The Kunga and Maude groups were deformed during or before emplacement of Yakoun volcanic feeder dykes (Bajocian) which may account for high paleotemperatures of Kunga strata on Moresby Island. (Souther)

Heating due to dyke emplacement has over-matured the hydrocarbon-bearing rocks, particularly near Skidegate Inlet-Moresby Island where dykes are more concentrated. (Souther)

The colour alteration index (CAI) of conodonts also indicates high paleotemperatures around Moresby Island. But the CAI of conodonts from the northwestern Queen Charlotte Islands (Kennecott Point) indicates maturation conditions well within the gas and oil window. (Orchard)

Study of the Sinemurian Sandilands Formation shows a marked decrease in volcanic debris (air fall tuff) from 50-60% of the sediments by volume in the Moresby-Skidegate area to nil in the northwest part of Queen Charlotte Islands (Kennecott Point). (Tipper)

The relationship between the dykes, airfall tuffs and thermal maturation levels remains to be established.

Bonilla Island on the east side of Hecate Strait was confirmed to be underlain by Karmutsen Group pillow lavas - part of the Wrangellia Terrane. The Wrangellia-Alexander Terrane boundary is therefore at least 80 km farther northeast than was considered before. Some 15,000 Km^2 of Hecate Strait, not previously thought prospective, is probably underlain by hydrocarbon source rocks and is hence suitable for oil exploration. (Woodsworth)

The Tertiary Masset Formation does not extend under Hecate Strait. It represents a short, hot eruptive pulse that had little thermal effect on older rocks or basin maturity levels. The unit is not a blanket but the product of a series of coalesced volcanic centres. (Hickson)

Evidence of sea-bed scour and shallow gas deposits, considered the commonest hazards to development in the region, were mapped in Queen Charlotte Sound and Hecate Strait. Sediments were cored to document and date submarine failures. (Luternauer)

Triassic ammonites and pelecypods were collected from several localities and systematic sampling for conodonts and for radiolarians were carried out simultaneously as part of biostratigraphic studies of these microfossils. (Tipper, Smith, Orchard, Carter)

Lower and Middle Jurassic ammonites were extensively collected and studied for comparison with radiolarian faunas as this region is one of a very few in the world where both occur together in this time interval. Hettangian ammonite and radiolarian faunas, not previously known in Queen Charlotte Islands were found. (Tipper, Smith)

The biostratigraphic studies serve for correlation of faunal assemblages and provide stratigraphic control for mapping and subsurface drill information. Because the Queen Charlotte material is exceptionally diverse, this work benefits Canada widely.

Energy Research and Development

Field work for this program was conducted jointly with an FGP cruise to Queen Charlotte Sound. About 800 km of side scan sonar and high resolution profiles were collected with 124 grab samples, 20 vibrocores, 5 dredges and 3 piston cores. Grain size analyses and radiocarbon dates are underway. Mobility of bank sediments due to intense scouring by high bottom currents are the main hazard to development.

A-base work in Yukon and Northern British Columbia

Systematic regional mapping of the Selwyn Basin, Yukon, which began in 1977 was finished with the completion of the Open File of the Tay River and Sheldon Lake geological maps. This area has been important for its giant lead-zinc deposits, such as Faro and Howard's Pass - this project recognized and promoted the gold potential of some of the rocks. (Gordey)

Studies of the Deadman pluton of the Tombstone plutonic suite (Dawson map area in the Yukon) indicates it's plutonic style combines features of the radiogenic Tombstone pluton and gold skarn - associated Mount Brenner pluton. (Anderson)

Progress is being made toward completing the regional gravity coverage of the Cordillera; at the current rate, about eight years should see the job done. This season gravity data were obtained from 650 stations in northern Yukon under a $390K contract funded jointly by FGP and A-Base and this completes regional coverage north of $64^{o}N$. Data were also obtained at 135 stations on Graham Island as part of the West Coast Task of the Frontier Geoscience Program. The gravity data were accepted into the national gravity data base. (Sweeney, Seemann)

Work continued in northwesternmost British Columbia (Yakutat, Tatshenshini River and Skagway areas), an area of current interest to the mineral exploration industry for its gold bearing massive sulphide deposits such as Windy Craggy. (Dodds)

Heat flow measurements were made on 45 boreholes in Queen Charlotte Islands, Yukon and northern and central B.C. and 40 marine heat flow measurements were made in Queen Charlotte Sound and Hecate Strait for control on thermal maturity levels in the Queen Charlotte Basin. Radioactive heat production samples were collected and U, Th, K and heat production were measured. (Lewis, Bentkowski)

A joint field trip in the Saint Elias Mountains with geologists from the U.S. Geological Survey Alaska Branch and Arco Exploration and Technology Company, shed new light on relationships between the Alexander and Wrangellia terranes, two large crustal blocks in the region. (Campbell, Dodds)

In the Spatsizi map area, B.C. study of the Bowser Lake Group (above the Ashman Formation) led to the recognition of four lithologic units which are useful in mapping. These strata are host to large anthracite deposits whose economics are

actively being investigated by Gulf Canada. (Evenchick)

Study of the Cold Fish volcanics continued. Because the rocks are equivalent to the Toodoggone volcanics, important gold bearing rocks farther east the new interpretations of their origin and structure will promote exploration in this remote region. (Thorkelson)

Previously flown and compiled aeromagnetic data over the Queen Charlotte Islands and continental margin were published in 77 geophysical maps. (Currie)

A-base work in Southern British Columbia

Earthquake monitoring - 51 seismograph stations are now operating in western Canada including 18 in the WCTN array, 8 in the Queen Charlotte regional array and 4 in the Beaufort - Mackenzie region (FGP). Between 800 and 1000 events a year are located in western Canada. The Dawson City station was lost in a fire this year and has not yet been replaced. (Weichert, Rogers)

Thirty-six strong motion seismographs operating in trigger mode are now installed in western Canada. The site at which acceleration twice that of gravity (a record anywhere) was recorded in 1985/86 was investigated. The site is reliable and this acceleration has to be believed. This groundmotion was accepted as an important criterion for design after it was presented at New York Academy of Sciences. (Weichert, Horner)

Sixteen "felt" earthquakes were reported in western Canada during the year. Public interest in earthquakes and particularly in the possibility of a large thrust-earthquake, remains high. A special flurry of public interest was set off by the 6.1 quake of October 1 1987 in the Los Angeles area. A number of radio and TV interviews were conducted by Weichert and Rogers in connection with this event and others.

Several large earthquakes occurred in our region in early November. The largest on November 7 (magnitude 6.8) was located in the Gulf of Alaska about 500 km SW of Whitehorse. On November 14 a series of quakes occurred near Haines Alaska; the largest was measured at 5.3. Aftershocks were felt on November 14 and November 17.

A widely felt (Delta, Richmond, Surrey, Vancouver and Victoria), magnitude 3 event was recorded September 16 and located just north of Whiterock B.C. On November 12 a similar event was recorded near Fort St. John and felt in Charlie Lake. (Weichert)

Analysis of data from the 1986 magnitude 5.5 earthquake near Prince George B.C. has been completed; it reveals thrust faulting as the cause. This and other focal plane solutions in the Foreland fold and thrust belt raises the question whether seismic hazard of the region is correctly assessed in Canada's current seismic zoning map. (Rogers)

A small area in the Coast Mountains south of Prince Rupert and near Exstall River was studied as part of a Master's degree project. The area is currently being explored for gold occurrences. (Gareau)

In the McLeod Lake area of central B.C. work centred on the nature of the contact between the Takla - Slide Mountain Assemblage and the Wolverine Complex. Because the contact is mylonitic where seen an important fault is inferred. (Struik)

Mapping in the Hope - Princeton area was completed. Field studies involved experts working in Washington State which refined the geological maps and interpretations of the region's geology. (Monger)

Deformation data near the southwest British Columbia coast suggest that elastic strain may be accumulating over a locked subduction zone. West Coast work in crustal dynamics involved analyses of previously collected data. Juan de Fuca GPS (Global Positioning System) survey data were analysed and reported. Ten years of precise gravity data from central Vancouver Island were analyzed. Mean-sea-level trends and repeated levelling data were analyzed. (Dragert)

Sampling for paleomagnetic studies was done on the Lower and mid-Cretaceous Kingsvale Group and Battlement Formation, on Kimberlite intrusions in the Main Ranges of the Rocky Mountains, on Quaternary volcanics and sediments of southern Vancouver Island, on Cretaceous intrusions in the Purcell Mountains, on the Coryell intrusions of southeastern B.C. on the Spences Bridge Group. (Irving, Wynne, Marquis)

Coal samples from Georgia Basin strata were collected for vitrinite reflectance studies by a PhD student supported by the Division. The work will provide a thermal and subsidence model of the basin. (Bustin)

Magnetotelluric field measurements were made in central Vancouver Island to monitor variation in resistivity. This may reflect stress accumulation associated with large earthquakes. Magnetotelluric measurements were also made across the northern Comox Basin to determine its geometry and electrical properties. Porous, fluid-saturated strata may be pinpointed this way. (De Laurier)

A-Base work on urban geology and seismic risk analysis

In April the Geological Survey of Canada completed its first deep drill hole (367 m) in the Fraser Delta, an urban/industrial area with about 7 percent of Canada's population in Canada's most seismically active area. The work is part of a continuing program to map the subsurface to improve earthquake risk assessment and to allow planners, engineers and scientists to more safely locate and better design structures to withstand tremors. The work helps determine the area's sensitivity to natural hazards and allows better hazard amelioration planning. (Luternauer)

The multidisciplinary project involved a gamut of studies and a range of scientists - from the Survey's Cordilleran and Pacific Margin and Terrain Sciences Divisions as well as staff and students of Simon Fraser University, University of British

Columbia and the University of Toronto.

Marine Work on the Pacific Margin and Offshore

The division carried out eleven cruises successfully. Camera tracks over the Juan de Fuca Ridge sulphide showings demonstrate that the occurrences are localized along the tectonic grain. Side scan, heat flow and sampling were done to investigate a large titaniferous sand resource with economic potential in Queen Charlotte Sound. Geohazards were mapped in the same region. Seismic, electromagnetics and heat flow surveys were carried out as part of an ODP site survey on two cruises. Seismic and magnetic surveys and sampling formed part of the East Pacific ODP site survey. Hemipelagic sediments high in carbonate were located. (Davis, Law, Luternauer, Bornhold, Rohr, Chapman, Lewis)

Global Geoscience Transects

The Global Geoscience Transect project (GGT), conceived in 1985 by the Inter-Union Commission on the Lithosphere (ICL), uses geological and geophysical data to explore the Earth's crust worldwide, and displays the results systematically to permit comparison of different parts of the world. Geological strip maps and vertical cross-sections are the products. (Monger)

GGT is modelled on the North American Continent-Ocean Transects Program, initiated in 1978 and whose products have been published since 1985 by the Geological Society of America. For this project, J.W.H. Monger of the Vancouver Office, GSC, coordinated compilation by ten scientists (half of whom were from GSC), of a crustal transect across the southern Canadian Cordillera and its Pacific margin. On the strength of this effort, he was invited by ICL President Fuchs to coordinate GGT in December 1985, and accepted the task in January 1986. His subsequent efforts have been devoted to getting GGT started worldwide, by setting-up regional/continental workshops and by publicizing the project, holding transect symposia at suitable venues worldwide with displays of drafts at the 28th International Geological Congress in Washington in 1989. The first meeting of the GGT Coordinating Committee was at the general assembly of the International Union of Geodesy and Geophysics in Vancouver in August, 1987. Regional workshops were held in 1987 in South America (May), in U.S.S.R. (September) in North America (October). In 1988 meetings will be held in Egypt (for African and Middle Eastern countries) and, it is hoped, in East Asia for Far Eastern and Australasian countries.

Personnel Notes

Dr. R.B. (Dick) Campbell, Director of the former Division retired on 31 March, 1987. Dr. D.J. Tempelman-Kluit took on the duties of Division Director; Dr. J.A. Roddick and Dr. L. Law are the subdivision heads at Vancouver and Sidney respectively. Dr. C. Evenchick joined the Division (in Vancouver) in October 1987, and Dr. C. Roots joined as a term employee in January, 1988. Mr. E.K. Wellar retired as head of administration in May 1987, and returned on one third time in October 1987 for the remainder of the fiscal year. Resignations at P.G.C. included Dr. D. Chapman in September 1987 and Ms. D. Chisholm at the end of the year. Dr. R. Higgs joined the Division (at P.G.C.) in February 1987 for a two year term, and Mr. B. Sawyer was appointed as an indeterminate employee for drafting in October 1987.

INSTITUTE OF SEDIMENTARY AND PETROLEUM GEOLOGY

W.W. Nassichuk

ISPG is responsible for establishing a sound geoscience base for the sedimentary basins of western and Arctic Canada, which occupy one-third the area of the country and contain most of Canada's oil, natural gas, and coal resources. In addition, units of the Division are responsible for the appraisal of the oil, gas and coal resource potential of the country.

The geological framework is being broadly outlined by current mapping and topical studies. These studies, together with paleontological investigations, support exploration for, and assessment of the non-renewable resources of western and northern Canada. Emphasis on energy resources has resulted in development of evaluation programs in both petroleum and coal, each supported by multidisciplinary basin studies. The geological evaluations contribute to the national inventories of oil, gas and coal resources.

The Institute is organized into six subdivisions: Regional Geology, Paleontology, Coal Geology, Petroleum Geology, Geological Publications and Administration, each comprising several sections. A seventh major administrative unit, the Petroleum Resource Appraisal Secretariat, also has a number of subordinate sections.

Regional Geology is responsible for preparing geological maps and lithostratigraphic and sedimentological reports for the principal sedimentary basins of Western Canada, Northern Mainland, Arctic Islands and adjacent offshore areas. Paleontology ensures precise and consistent biostratigraphic correlation, by refinement, through detailed taxonomic and stratigraphic studies, of the biochronologic scale which serves as the basis for biostratigraphic correlation. The Coal Geology Subdivision is responsible for defining and characterizing Canada's coal resources in support of exploration and possible exploitation. The Petroleum Geology Subdivision objectives are to identify the oil and gas resource base of Canada and to determine the origin, probable distribution and potential abundance of oil and gas resources. The Geological Publication Subdivision is concerned with processing, publication and dissemination of information on Canada's sedimentary basins and resources. Activities in the four scientific subdivisions at ISPG, that is the Regional Geology, Paleontology, Coal Geology and Petroleum Geology in concert with the Petroleum Resource Appraisal Secretariat reflect the four Strategic Objectives of ISPG as follows:

1. To map, describe and explain the bedrock geology of sedimentary basins in western and northern Canada.

2. To develop and modify biochronologic standards essential to correlation and comprehension of bedrock geology in the sedimentary basins of western and northern Canada.

3. To assess the probable distribution and potential abundance of the oil and gas resources of Canada.

4. To investigate the geology of coal deposits in western and northern Canada; to determine distribution, quality and quantity of coal deposits; to develop a capability to provide authoritative advice on Canada's coal resources.

The Adminstration Office provides financial services, central registry, stationery and supplies, and office services. A world class geological library, available to the public, is under the jurisdiction of the Administration Subdivision. ISPG maintains and administers its building owned by the Department of Energy, Mines and Resources, and as a result building and engineering services are an important component within Administration.

The present establishment of the Institute is 168 person years including 82 scientific and professional positions, 8 operational, 41 technical, 4 administrative and foreign service, and 33 administrative support positions.

A repository is maintained for samples, core and other data resulting from both onshore and offshore exploration drilling by industry in the Yukon Territory, the Northwest Territories, including the Arctic Islands and for samples from all provinces and continental shelves of western Canada. Most of the material is available to the public for free examination and is used by the ISPG in research activities.

ADMINISTRATIVE SUBDIVISION

K.M. Cameron

The objectives of the Administrative Subdivision are directed toward providing efficient and timely administrative, financial, library, logistical, instrument development, electronics and building maintenance services to the Division.

During the fiscal year 1987/88, the Subdivision was comprised of a full-time continuing staff of 22. During the fiscal year, the following staff changes occurred:

Transfers

Mr. P.K. Errmann, an EG-ESS-09, was transferred from Indian and Northern Affairs to the ISPG Building Engineering staff on April 19, 1987.

Mr. D.J. Allan, an EL-04, was transferred from the Ministry of Transport to join the Administrative staff on March 24, 1988.

Appointments

Mrs. R. Roebroek, an LS-03, was appointed to the ISPG Library staff as Head Librarian on May 19, 1987.

Promotions

Mr. D. McInroy was promoted from an STS-03 to a CR-03 and appointed to the Curation Section of the Paleontology Subdivision.

Ms. T. Fazel was promoted from a CR-02 to a CR-03 and appointed to the Accounts and Finance Office in the Administrative Subdivision.

ISPG LIBRARY

Acquisitions	1986/87	1987/88
Books acquired by purchase	529	533
Books acquired by gift or exchange	937	1215
Maps added	357	312
Periodical issues added	2836	3026
Circulation		
Books and periodicals (to staff)	7855	9300
Inter-library loans:		
Borrowed	250	380
Loans and photocopies	269	330
Reference		
Phone queries handled	900	905
On-line searches	37	533

Comment

On-line searches rose dramatically during the year due to an increased expertise and awareness among library staff of on-line sources and applications. Significantly more use was made of on-line databases for traditional literature searches, reference queries, bibliographic verification and library-related functions.

Systems

An examination of Minisis applications in use at the GSC Library in Ottawa resulted in the decision to adopt the GSC version at ISPG. Besides standardizing the system used throughout EMR, significant advantages to the ISPG include: back-up expertise from a systems position in Ottawa, man-years of completed database development, shared cataloguing records, Minisis training for ISPG staff, and the potential for greatly increased networking capabilities among GSC libraries.

Space

The Library shared in the acute space problem currently faced throughout the ISPG; however, significant strides were made in alleviating the problem. Use of a newly designated storage area allowed staff to free 24 single-faced bays of shelving for future expansion. The entire catalogued collection was shifted to integrate the space where it would be required. In addition, staff developed a floor plan for future use which rearranges the current amount of shelving into a new configuration occupying approximately 3/5 the current space.

Series Evaluation

The rising proportion of the Library budget allocated to maintaining the journal collection prompted a journals evaluation with the scientific staff. Every title for which there was limited or no support was questioned. Savings will be used to offset the cost of new subscriptions and other price increases.

Indexing

Three major indexing projects were initiated during the fiscal year: the indexing and integration of the backlog of donated materials with the main library collection, the treatment of well known series with a series call number, and an examination of the feasibility of downloading catalogue records from GEOSCAN, the GSC Library and other databases to speed the conversion from card catalogue records.

REGIONAL GEOLOGY SUBDIVISION

D.G. Cook

The objectives of the Regional Geology Subdivision are directed toward the increased understanding of the depositional and deformational history of Proterozoic and Phanerozoic sedimentary rocks of Western and Arctic Canada. The investigations provide the data base essential for the appraisal of the economic potential of these sedimentary suites, both as reservoirs for, and sources of, oil and gas; and as host rocks for other economic deposits including coal, potash, lead, zinc, copper, precious metals and industrial minerals, and for the exploration and exploitation of these resources. Programs integrate field structural, stratigraphic, and sedimentologic studies; subsurface studies; analysis of industry derived seismic data; the acquisition of and analysis of refraction, seismic, and deep reflection seismic data; and the acquisition and interpretation of gravity and aeromagnetic data. Regional Geology's programs are co-ordinated with those of Paleontology, Petroleum Geology and Coal Geology Subdivisions.

The Regional Geology Subdivision is organized geographically, partly in response to similar geological problems and partly because of similar logistical problems. It comprises three sections. The Arctic Islands Section is responsible for the sedimentary areas of the Arctic Islands, with geological investigations being concerned mainly with rocks of the Franklinian Geosyncline, Stable Platform, Sverdrup Basin and the continental shelf. Most of the Arctic Islands activities are funded through the Frontier Geoscience Program. Projects include surface and subsurface structural, stratigraphic and sedimentologic studies, and reflection and refraction seismic studies on the continental shelf, carried out from an ice island research station. The ice island projects are being carried out in co-operation with Terrain Sciences Division, Geophysics Division and Atlantic Geoscience Centre. The Northern Mainland section is concerned with sedimentary regions of the Yukon and Mainland Northwest Territories, including the Mackenzie Delta and Beaufort Sea. Most activities are funded under the Frontier Geoscience Program. Surface and subsurface structural, stratigraphic, and sedimentologic studies are integrated with the study of deep structural geometry of sedimentary basins by the application of geophysical techniques, specifically reflection and refraction seismic, gravity, and aeromagnetic. The Southern Mainland Section is responsible for sedimentary rocks of the Western Canada Sedimentary Basin lying within the prairie provinces and eastern British Columbia, the main focus of oil and gas exploration and exploitation in Canada. The Southern Mainland falls outside of the Frontier Geoscience Program, and activities are essentially confined to surface and subsurface structural, stratigraphic, and sedimentologic studies.

The Institute is the repository for cutting and core samples, and other data resulting from both onshore and offshore exploration drilling by industry in Yukon Territory, Northwest Territories (including the Arctic Islands), East Coast offshore, and for samples from all provinces of Western Canada. Some 13,000,000 samples and 28,000 boxes of core are stored at the Institute; the number of samples increases by about 400,000 each year. With the exception of samples from wells in Alberta, all are available to the public for free examination. Alberta samples are provided to the public by the Alberta Government, for a small fee. Files are maintained of all the logs and other data related to more than 70,000 wells drilled in Western and Arctic Canada. The facility, including the core storage, sample storage, sample examinations, core examinations, log storage and administration areas, covers 4866 square metres. The retention of a third person on term employment has permitted the maintenance of improved service to the public including remaining open over noon-hour, and giving a full library withdrawal and refiling service with respect to the well log library.

Arctic Islands

Regional 1:250 000 scale mapping of northwestern Devon Island was completed. The Late Cambrian to Ordovician shelf margin, characterized by large stromatolite reefs, was located on western Grinnell Peninsula. The Grinnell and Douro ranges were found to consist of a series of tight, variably verging, faulted anticlines which have a basal detachment surface in Ordovician evaporites.

Mapping at 1:250 000 scale was completed on Prince Patrick and Eglinton islands. The Parry Islands Fold Belt was found to continue westward onto southern Prince Patrick Island. North-south normal faults, which were active from Middle Jurassic to Late Cretaceous, occur on southeastern Prince Patrick Island. East-west open folds (early Tertiary) were discovered on northern Prince Patrick and Eglinton islands.

Eight depositional sequences were recognized in the outcropping Jurassic succession of Prince Patrick Island. These sequences can be correlated to subsurface sections in the area as well as to other areas in the Sverdrup Basin. Although many of the sequences seemingly can be correlated on an intercontinental scale, various features of the sequences indicate that tectonism was the critical variable for their origin.

A regional gravity survey was conducted on northwestern Ellesmere Island and northern Axel Heiberg Island. Survey results will complement present and future geological and geophysical studies of this area, which comprises much of the Eurekan Orogenic Belt.

One 1:1 000 000 scale Geological Atlas map was submitted to cartography. Data were acquired from industry and AGC staff to augment compilation of offshore geology for a second map which is nearing completion. Compilation continues for two other maps. The 1:2 000 000 and 1:5 000 000 maps of the Arctic Islands were completed and submitted to DNAG editors. A successful trip was made to Leningrad during which agreement was reached on format, standards, areas of responsibility and schedules for the 1:10 000 000 circum-Arctic map and geotectonic correlation chart of the joint Canada/USSR Arctic project.

Geological comparisons were made between the Chukchi Sea and western North Slope areas of Alaska, and the Prince Patrick and Melville Island areas of the Canadian Arctic Archipelago, using seismic sections and gamma-sonic logs from exploration wells. Striking correlations of stratigraphic and tectonic features became apparent. This evidence strongly supports the plate tectonic model of counter-clockwise rotation of northern Alaska and adjacent Siberia away from the Canadian Arctic Islands to form the Amerasian portion of the Arctic Ocean.

The first known fossil occurrences of hydrocarbon cold seep communities have been discovered on Ellef Ringnes and Prince Patrick islands. Abundant Cretaceous serpulid worm tubes and bivalves, associated with mound-like methane-derived carbonates, occur adjacent to synsedimentary extensional structures that are interpreted to have tapped various hydrocarbon sources in the subsurface. Gases, and perhaps oil, probably seeped to the surface, providing the energy source to oxidizing bacteria, upon which the higher organisms fed. Nearly identical "life oases" and associated carbonates currently occur near hydrocarbon seeps in the Gulf of Mexico and in the North Sea.

Fieldwork on the "fossil forest" of Geodetic Hills, Axel Heiberg Island, was organized; field teams from several institutions were hosted by a Geological Survey of Canada field party and studies were conducted in sedimentology, paleosols, paleobotany, forest dynamics, paleozoology, and site preservation. A commerical film crew recorded the activities and interviewed the scientists.

Structural cross-sections and reprocessed seismic reflection data of eastern Melville Island are delineating upper Paleozoic rift-related structures beneath the Sverdrup Basin that are perched above Ellesmerian thrust anticlines. Reflection seismic data from Melville Island is also revealing details of a Proterozoic deformed terrane beneath 10 to 12 km of Paleozoic strata.

Northern Mainland

In preliminary mapping of complex Ellesmerian structures of the Barn Uplift, northern Yukon, it was found that pre-Carboniferous Paleozoic strata consist of only a few hundred metres of argillites, cherts and minor limestone repeated numerous times by north trending Ellesmerian thrusts and isoclinal to tight folds.

Studies of the level of organic maturity of lower Paleozoic strata of the Northern Yukon were initiated. Previous work has indicated the presence of thermal discontinuities in the Paleozoic and Mesozoic sequences of nearby areas which will strongly constrain models for their thermal and burial history.

Three marine deep seismic reflection profiles aggregating 550 km in the southern Beaufort Sea were shot and recorded by Geophoto Services Inc., from August to October. One transect crosses the Eskimo Lakes Arch north of the Tuktoyaktuk Peninsula; another extends FGP 86-1 offshore across the continental shelf; and a third crosses the Mackenzie Trough.

Preliminary mapping in the Blow River area, northern Yukon, has shown that the Rapid Fault Array is dominated by north-south trending folds of probable Eocene age,

correlating with a seismically defined arcuate deformed belt under the Beaufort continental shelf. These structures are kinematically linked to Brooks Range deformation.

A deep crustal seismic refraction program, consisting of 940 km of in-line and 650 km of broadside profiles, was completed in April. Preliminary interpretation and modelling of the data are consistent with a crustal model, involving Mesozoic extension superimposed onto an older continental crust of Proterozoic or early Paleozoic age.

Southern Mainland

A field study documenting complex facies changes and disconformities in the late Paleozoic succession, along the southern margin of the Peace River Embayment was successfully completed.

Subsurface study of the Devonian succession across the western part of the Peace River Arch was initiated. Overlap by Middle Devonian strata in this area appears to be more extensive than previously thought.

Three contract field studies were successfully completed. Study of thrust transfer zones in the central Alberta Foothills aided in the completion of two 1:50 000 A-series maps (Mountain Park, Cardinal River; 83C/14,15). Complex facies changes and disconformities in Ordovician to Lower Devonian strata were documented, and a major structural detachment, separating a Main Ranges fan-fold complex from Front Ranges structures, was outlined in the White River region, B.C. (82J/3,6). Thickness and facies changes in Upper Proterozoic strata exposed in a large upright anticlinorium south of Valemont, B.C., indicate the presence of a syndepositional western outboard high.

Decade of North American Geology

The two volumes in preparation at ISPG are parts of a thirty-two volume series, organized by the Geological Society of America, dealing with the geology of North America and its bounding oceanic plates. They constitute parts of the decennial revision of the Geological Survey of Canada's series, "Geology and Economic Minerals of Canada".

The volume, "Sedimentary Cover of the North American Craton: Canada" deals with the sedimentary basins of Canada outside the Canadian Shield and the orogenic belts, namely, the Western Canada Sedimentary Basin, Hudson Platform, and St. Lawrence Lowland. It presents a concise account of the depositional and tectonic history and the resources of the basins. The interpretations and much of the data are new. The volume will comprise about 600 pages and 450 text illustrations. A complete draft, lacking only the section "Petroleum Geology", was submitted to outside reviewers and the series co-ordinator in May 1987. Re-writing and final editing began on a piece-by-piece basis in March 1988.

The remaining two (out of 21) chapters of the volume "Innuitian Orogen and Arctic Platform: Canada and Greenland", and two additional subchapters were submitted, and the entire volume was reviewed and approved by two external referees and the Canadian series editor, Dr. J.O. Wheeler. Final scientific and technical editing are progressing and it is expected that the volume will be submitted for French translation by June 1988.

Personnel Notes

Dr. J.D. Aitken was presented with the R.J.W. Douglas Medal by the Canadian Society of Petroleum Geologists at the society's Awards Dinner and Dance in March 1988. This award is for career accomplishments, and is in recognition of outstanding scientific contributions to the understanding of sedimentary geology in Canada, with emphasis on regional tectonics and petroleum and structural geology.

Drs. R.L. Christie, R. Thorsteinsson, and H.P. Trettin were presented with the Professional Institute's Gold Medal, for meritorious achievement in the study of Arctic Islands geology, November 1987.

Dr. B. Beauchamp joined the staff on June 21, 1987 as a carbonate sedimentologist in the Arctic Islands Section. He came to us from the University of Calgary.

Mr. J.C. Harrison returned from education leave at Rice University, Houston, in time for the 1987 field season. He is finishing the writing of his thesis.

Mr. N.C. Meijer Drees took 5 months' education leave at Utrecht University, Holland to work on his Ph.D. He returned August 1987 and is writing up his thesis.

Dr. L. Maurel joined the Regional Geology Subdivision, as a Post Doctorate Fellow, on June 22, 1987, under the supervision of Dr. U. Mayr, studying the Douro Range on Grinnell Peninsula, Devon Island.

Dr. G.M. Ross joined the Regional Geology Subdivision, as a Post Doctorate Fellow, on August 1, 1987, under the supervision of Dr. J.D. Aitken, studying Precambrian Miette Group stratigrahy and provenance.

Mr. P. Van Dyk started as a casual STS-4 in the Core and Sample Repository on June 19, 1987.

Mr. A. Scott started as a casual STS-3 in the Core and Sample Repository on October 30, 1987.

Mr. J. Mamo worked as a casual CR-3 from October 5, 1987 to March 31, 1988.

Mr. P. Wozniak started as a casual CR-3 on January 18, 1988.

Core and Sample Repository

Well samples received:

Alberta	226,144
British Columbia	31,596
Saskatchewan	21,418
Manitoba	nil
Offshore	4,050
Territories	4,275

Mechanical logs received (Alberta, British Columbia, Saskatchewan, Manitoba and the Territories)	3,631
Territories core received (boxes)	167
Visitors requiring core, samples, or related information	1,730

9383 boxes of core were made available for examination and samples from some 1508 wells were requested.

Cuttings or core from 215 wells were sampled for various scientific purposes by a variety of oil companies, geological laboratories, and our own scientific staff.

PALEONTOLOGY SUBDIVISION

B.S. Norford

The Paleontology Subdivision is responsible for interpretation of the fossil record in Canada through studies in biostratigraphy, paleoecology and systematic paleontology. These investigations provide data that support regional mapping and stratigraphic studies, and exploration for hydrocarbons, metals and other non-renewable resources and assessment of these resources. Most of the Subdivision's activities are in northern and western Canada, although a significant number of projects also deal with basinal areas in central and eastern Canada (onshore). In all these areas, paleontology plays an important role in GSC basin analysis programs.

The Subdivision develops and maintains biostratigraphic standards for regional and international correlation and carries out a continuing program for improvement of zonal schemes and refinement of paleo-environmental interpretations. Most projects are directed toward fossil groups that display rapid evolutionary changes and are therefore particularly useful for biostratigraphy; occasionally less well known fossil groups are tested for biostratigraphic potential and application as well. A large part of the program involves dating and correlation by means of detailed studies of fossils recovered from cuttings and cores from northern and offshore wells.

The Subdivision consists of the Micropaleontology Section, the Macropaleontology Section, the Ottawa Paleontology Section (including both micropaleontology and macropaleontology), and the ISPG Curation Unit. Micropaleontological studies, mainly on palynomorphs, foraminifers, conodonts, and ostracodes, involve material from both surface and subsurface with emphasis on subsurface well material from frontier and offshore areas. Macropaleontological studies, on a wide variety of groups, deal mainly with surface material, but include some material from subsurface cores. In addition to paleontological studies, members of the Subdivision conduct stratigraphic studies in cooperation with other units of the Geological Survey of Canada. The Curation Unit is responsible for receipt, documentation, cataloguing, storage, information retrieval and loans of GSC field and subsurface samples from the Calgary and Vancouver offices.

Research and service programs within the Subdivision are closely coordinated with those of other Subdivisions of the ISPG, with similar programs in other divisions of GSC, and with programs of outside government agencies, universities, and industry in Canada and other countries. The function of the Subdivision is conducted, in part, through contracts with consulting companies and university scientists, supervised by scientists within the Subdivision. In addition, a number of EMR Research Agreements, arranged with scientists outside the Survey, are administered by the Subdivision. The Subdivision continued its participation in Frontier Science Program activities on the Arctic Islands and Western Arctic and began participation in the West Coast activity (Queen Charlotte Islands).

Paleotemperature studies, both as an aid to hydrocarbon and mineral exploration and as a contribution to the history of the burial and uplift of sedimentary basins, are increasingly being pursued in the Subdivision. The principal fossil groups used as maximum thermometers include conodonts, graptolites and palynomorphs. Fossil interpretations and colour assessments are carried out by paleontologists in both Calgary and Ottawa; quantification of maturity assessments is being developed in cooperation with scientists of the Coal Subdivision.

Subdivision scientists and associated outside specialists completed 161 paleontological reports on 2503 collections of fossils from outcrop and subsurface. These reports were prepared for direct quotation in publications and provided dating, correlations and hydrocarbon maturity data of rock units throughout Canada for use by the GSC, other EMR agencies, the Department of Indian and Northern Affairs, industry, and provincial government agencies, such as the Alberta Geological Survey. Five paleontological manuscripts for the GSC Bulletin series were edited and finalized on contract during the year.

International collaboration included formal interchange with the All-Union Research Institute for Geology and Mineral Resources of the World Ocean (Leningrad), visits to Calgary by specialists from Belgium, Poland, Australia, China, England, Germany, Norway and the United States, and visits by Subdivision scientists to India, Poland and the United States. Several members of the Subdivision participated in IUGS Stratigraphic Subcommissions and Working Groups as Canadian representatives. These included Canadian leadership and organization of a 1987 inspection of a potential Precambrian-Cambrian boundary stratotype in Newfoundland. Drs. A.W. Norris and A.E.H. Pedder contributed to the organization of the field trips and session of the Devonian Subcommission's 1987 meetings in Calgary.

Personnel Notes

The Subdivision includes 30 permanent positions (19 scientists, 7 technicians, 2 secretaries, 2 curators) as well as 18 contract workers and a varying number of temporary and summer assistants. In Calgary, Dr. B.S. Norford continued as Acting Subdivision Head. Drs. A.W. Norris and M.J. Copeland moved to part-time status during the year but sustained their customary productivity. Denise Then and Jean Dougherty of the micropaleontology lab, came through with the final results of their personal production programs – both are proud mothers of baby girls. Brenda Davies has been running the foraminiferal lab for the latter part of the year and Geneviève Johnson is temporarily replacing Brenda in the palynology lab. Maureen Smith resigned her position as technician with responsibilities to Macropaleontology and to the conodont lab. Gideon Smith resigned from the curation clerk position. The successful applicant to fill this position is Dale McInroy.

In the Ottawa Paleontology Section, Dr. J.W. Haggart joined the Survey to work on Cretaceous and Upper Jurassic biostratigraphy, primarily using ammonites. Jim will be located in the Calgary office in the fall. H. McLaughlin was successful in obtaining permanent part-time status as lab technician.

Visiting Scientists During 1987/88

Dr. P. Bultynck, Institut Royal des Sciences Naturelles De Belgique, Brussels; Dr. William Oliver, USGS, Washington, U.S.A.; Dr. G. Biernat, Polaska Akademia Nauk, Warszawa,

Poland; Dr. H. Jaeger, Palaontologisches Museum, Humboldt Universitat, Deutches Demokratik Republic, Germany, Dr. J. Fedorowski, University of Poznan, Poland; G.M. Phillips, University of Sydney, Australia; R.T. Becker, der Ruhr - Universitat Bochum, West Germany; R. Birenheide, Natur-Museum und Forschung Institut Senckenberg, West Germany; P. Carls, Institut für Geologie und Paläontologie, West Germany; Liao Wei-hua, Nanjing Institute of Geology and Palaeontology, Nanjing, People's Republic of China; T. Wrzolek, Silesian University, Poland; Yu Chang-ming, Academia Sinica, Nanjing, People's Republic of China.

Laboratory Statistics - Calgary

Foraminifer Laboratory

A total of 649 samples were disintegrated during the fiscal year. Samples came from Jurassic, Cretaceous and Tertiary strata in the Sverdrup Basin, the Beaufort-Mackenzie Basin, and the Western Canada Basin. The samples comprised 284, primarily from the Beaufort Sea exploration wells, and 365 from outcrop studies undertaken by the subdivisions of Regional Geology and Paleontology. The extraction of microfossils by picking was contracted out through the Department of Supplies and Services.

Conodont Laboratory

349	samples processed and picked
87	samples processed only
51	samples picked only
57	samples viewed (check picking and estimate grain percentage)

Of the above, 168 were well samples while the remainder were outcrop samples. Material was processed for T.T. Uyeno.

Outside Contracts

279 samples contracted out for processing
176 samples contracted out for separate picking

Palynology Laboratory

1516 samples from surface and subsurface were processed for miospores for studies by Drs. D.J. McIntyre, A.R. Sweet, J. Utting and J.M. White. The laboratory provided training in palynological techniques as part of a post-graduate course in Organic Petrology and Geochemistry, operated at ISPG.

Macropaleontology Laboratory

The major output consisted of 1347 coral and foraminiferal thin sections for study by Drs. A.E.H. Pedder, E.W. Bamber and B.S. Norford and paleontologists outside ISPG. Casts and moulds of the fossils numbered 22, fossils were picked from 2 acid residues.

Curation Statistics - Calgary

"C" numbers issued	8,000
Transferred from Ottawa	200
Samples circulated within ISPG	3,508
Samples shipped out for processing, study loans, gifts:	1,220
GSC Ottawa	320
GSC Vancouver	200
Other institutions/contracts	722

The above institutions include 2 foreign government agencies, 3 Canadian and 6 foreign universities, 2 Canadian and 3 foreign companies.

Reports entered in to Internal Report Computer listing	200

Laboratory Statistics - Ottawa

Lapidary Laboratory

Rock thin sections	
Standard, produced by laboratory	555
Large, produced by laboratory	95
Standard, produced on overtime	2,003
Large, produced on overtime	104
Standard, prepared for outside contract	1,462
Large, prepared for outside contract	49
Polished, produced by laboratory	9
Polished, prepared for outside contract	886

Paleontology Laboratory

Preparation:	
Thin sections	238
Plaster casts	234
Latex Rubber moulds	4
Silicone Rubber moulds	13
Epoxy casts	4
Presentation pieces	35
Polished surfaces	90
Curation:	
Parcels received	157
Parcels shipped	90
Fossil localities catalogued (GSC Localities 102202 to 103907)	1,706
Collections received with Calgary numbers	356

Palynology Laboratory

In the Ottawa palynology laboratory, supervised by D.C. McGregor, G. Buckler processed 181 surface and subsurface samples were processed, and 644 slides were prepared containing marine and nonmarine palynofossils and 169 specimens for study by scanning electron microscope.

Conodont Lab

In the Ottawa conodont laboratory, supervised by G.S. Nowlan, 389 samples were processed and picked.

TYPE SPECIMENS CATALOGUED IN 1987 (THOMAS E. BOLTON, CURATOR)

PUBLICATIONS	Camb.	Ord.	Sil.	Dev.	Carb.-Perm.	Trias.	Jur.	Cret.	Tert.-Recent	Total	Nfld	NS	NB	Que	Man	Alt	BC	Yuk	NWT	Other
GSC Bulletins																				
346 (Algae)					379					379									X	
358 (Ammonites)							210			210								X		
371 (Cysts)									350	350									X	
374 (Spores)					119					119		X								
375 (Brachiopods)				84						84									X	
GSC Papers																				
86-1B (Ammonites)							4		4									X		
86-20 (Pelecypods, Ammonites)							9			9							X			
87-1A (Palynomorphs, Conodonts)			3	6		43	52									X		X		
SUBTOTALS (GSC)				87	504	-	210	13	393	1207										
Canadian Journal of Earth Science (Microflora, brachiopods, graptozites, algae, sponge, ammonites, trace, conodonts, gastropods, chitinozoa)	10	306	11	1		33	25	103			523	X	X	X	X	X		X	X	
Journal of Paleontology (Palynomorphs, corals, pelecypods, brachiopods)	46	1	22							69			X		X			X	X	
Other (Brachiopods, arthropods, ammonites, palynomorphs, corals, conodonts, ostracodes, conularids, pelecypods, forams, plants)	1351	131	195	15	41	4	20	748	7	2412	X			X		X	X	X	X	X
SUBTOTALS	1407	438	128	16	41	37	45	851	41	3004										
TOTAL	1407	438	128	103	545	37	255	864	434	4211										

PETROLEUM GEOLOGY SUBDIVISION

R.W. Macqueen

Petroleum Geology Subdivision personnel conduct research centred around the habitat of hydrocarbons in basins of Western and Arctic Canada (except for Organic Geochemistry, which has a national mandate). This involves studies mainly on a regional scale and mainly based on subsurface information, but outcrop studies and local subsurface studies on the scale of individual reservoirs are an important and continuing part of some projects. Subdivision personnel draw on other strengths of the Institute as required or appropriate, including regional geology, paleontology, organic petrology and coal geology, and approaches developed in the Petroleum Resource Appraisal Secretariat (PRAS). Petroleum Geology Subdivision personnel are active contributors to the continuing resource appraisals of PRAS: four of the seven authors of the widely acclaimed GSC paper 87-26, Conventional Oil Resources of Western Canada, are based in the Subdivision. These and other personnel will be playing a leading role in the development of a natural gas appraisal of the Western Canada Basin that has been initiated by PRAS.

Funding of the work of the Subdivision is provided from A-base, Petroleum Energy Research and Development (PERD), and Frontier Geoscience Program (FGP), reflecting the emphasis on energy-related studies. There is an increased emphasis on cooperative projects such that geological, geochemical, paleontological and geophysical aspects of areally-based projects are as fully addressed as possible, through collaboration with personnel of other subdivisions, contract work, and university and industry cooperation, as appropriate. Examples include Beaufort-Mackenzie studies (mainly FGP-funded), and the Peace River Arch project (mainly PERD-funded). The Peace River Arch project is a program of collaborative research with personnel of the Alberta Research Council/Alberta Geological Survey, which began formally in April, 1987, and is aimed at producing a synthesis volume by the fall of 1990.

Petroleum Geology Subdivision has three sections: Resource Geology under D.A. Leckie, Geophysics under R.A. Stephenson, and Geochemistry under L.R. Snowdon. The first two of these sections have been in operation for only a year, and are proving useful and worthwhile.

Work of Resource Geology and Geophysics personnel consists of geological and geophysical studies at several levels: from that required to understand individual stratigraphic units and hydrocarbon plays, up to the level of studying the behaviour of entire sedimentary basins through time. Some of the work of these individuals is coordinated, through PRAS, with related activities within ISPG and with requirements of the Canada Oil and Gas Lands Administration (COGLA). The major activity of all personnel of the Subdivision is to participate in research projects that are aimed at understanding the origin, migration and occurrence of hydrocarbons in Canada, within the context of evolving sedimentary basins. In-house, cooperative, and contractual work has this goal.

Geochemistry Section personnel provide organic and inorganic geochemical services to a broad spectrum of workers and projects at ISPG: the organic geochemical facility is identified as GSC's National Organic Geochemical Laboratory. Organic geochemistry personnel are playing a leading role in the new Queen Charlotte Basin project, Pacific Continental Margin, and are continuing to play an important role in geochemical studies of Atlantic Continental Margin basins. The organic geochemical laboratories utilize a wide range of sophisticated analytical tools, including kerogen isolation and classification, solvent extraction, and gas chromatography of certain hydrocarbon fractions. Exciting new approaches carried out in the section involve the study of geochemical fossils or biomarkers, of great value in oil-oil and oil-source correlations. The hybrid triple sector mass spectrometer provides a superb capability for the isolation and identification of individual biomarkers from complex mixtures such as are found in certain Canadian basins (e.g., Jeanne d'Arc Basin, Atlantic Continental Margin). Delivered last year, this facility is an outstanding success.

Until this past year, organic geochemical studies have been carried out on material from frontier areas, including the Arctic Islands, Mackenzie Delta – Beaufort Sea, Atlantic Continental Margin, and Queen Charlotte Basin. There is an increasing need to examine oils, oil-source correlations and related aspects of the Western Canada Basin, however. This work is developing, especially through PERD funding of Williston Basin (Saskatchewan) work, and with renewed study of tar sands/heavy oils.

Inorganic geochemical work involves X-ray diffraction, X-ray fluorescence, analytical chemistry and scanning electron microscopy, as well as a number of other less commonly used approaches (e.g., infra-red spectroscopy). In addition to providing analytical services for ISPG, these facilities are used to carry out research in the field of diagenesis related to the hydrocarbon-generating potential of source rocks and the development of authigenic minerals in reservoirs.

The Petroleum Geology Subdivision also has responsibility for maintaining geological and geophysical reports obtained from COGLA, and pertaining to seismic surveys conducted in frontier areas including the Arctic Islands, Beaufort-Mackenzie, and Lower Mackenzie river areas.

Highlights – Petroleum Geology Subdivision

Our organization of subdivision personnel into three discipline-oriented sections is now a year old, and is proving advantageous. As well as reflecting the fact that many subdivision personnel are involved in studies within a number of geographic or geological regions, these sections give greater visibility to the main activity identified, be it resource geology, geophysics, or geochemistry.

Resource Geology

For the Western Canada Basin, the collaborative Peace River Arch study (with the Alberta Geological Survey) began officially in 1987. A format for the main publication expected from this activity has been identified, along with authors and tentative sections and chapters. Two progress meetings have been held. Personnel from all of ISPG's subdivisions and the Petroleum Secretariat are involved. Two component studies of this activity are well along: these include a regional subsurface petroleum geology study of the Mississippian Stoddart Group in the Arch environs, and a similar study of the Cretaceous Peace River Group, in part to assess the effects of eustatic sea level changes on the distribution and character of source and reservoir facies. Study of the 1.3 km Lower Cretaceous core from the Monkman Pass area has led to several submitted manuscripts

outlining paleosols, micropaleontology of the Peace River Formation, and maturity level/source rock potential of the cored interval. Meanwhile a major study has begun in southern Alberta, partly utilizing consultants, to attempt to understand more clearly the character, distribution and origin of Lower Cretaceous Mannville Group hydrocarbon reservoirs. A major goal of this work is the construction of a facies model for these complicated and diverse reservoirs, tied to sea level changes, tectonic pulses of sediment, subaerial exposure, and superposed complex channel fill deposits resulting from the interplay of these and other factors. At the level of reservoir studies, the Lower Cretaceous southern Alberta Cessford pool investigation is complete, whereas the Upper Cretaceous Doe Creek study, central Alberta, continues. Aspects of many of these studies will be presented at a CSPG core conference to be held in September, 1988, and to be co-chaired by D.A. Leckie, Resource Geology Section Head and 1987 CSPG Medal of Merit winner for the best petroleum geology paper published in 1986.

In the Saskatchewan portion of the Williston Basin, geological and organic geochemical findings continue to arouse sizable oil industry interest. Four families of oils have been recognized, thanks in part to the analysis of more than 200 conventional oil samples acquired through collaboration with the Saskatchewan Department of Energy and Mines. Oils also have been obtained from North Dakota for comparative purposes. Based on the occurrence of a specific source rock facies and anomalous area of high heat flow and therefore enhanced maturity levels, an exploration fairway map has been produced and published from this OERD-funded project, for the active Middle Devonian Winnipegosis pinnacle reef oil play.

A brief comparative study on the Sweetgrass Arch and Peace River Arch is in press, and demonstrates that the two features are distinct in origin, geological age, and tectonic history. Collaboration with University of Alberta Department of Physics personnel has continued, with the production of the last of four 1:1 million heat flow maps of the northern Alberta region.

Studies in and around the Mackenzie Valley Corridor continued, with this year's progress including an open file report on the regional surface and subsurface geology of the Bonnet Plume area, and systematic regional study of thermal maturity by a post-doctorate fellow at ISPG. A contract study on the northern part of the region, Tuktoyaktuk Peninsula, has outlined the nature of the previously poorly understood sub-Mesozoic succession, and is thus of direct interest in interpretation of the nearby Beaufort-Mackenzie deep reflection seismic line. Plans are to release the report as an open file, and to publish the findings as a GSC paper. In the Anderson Plains region, more than 15,000 km of COGLA-acquired industry derived seismic reflection data have been obtained, organized and evaluated on contract, thus adding to our knowledge of the subsurface from this important data resource.

For the Arctic Islands, Resource Geology personnel continued study of Triassic Schei Point group cored sand-shale facies, and advised and facilitated studies of Sverdrup Basin volcanic rocks being carried out at Dalhousie University at the Masters and Doctoral levels.

Members of the Subdivision continue to contribute to research being compiled by the Petroleum Resource Appraisal Secretariat: as stated elsewhere, four Resource Geology researchers were co-authors of the recently published GSC paper 87-26, Conventional Oil Resources of Western Canada. The newly evolving Western Canada Basin natural gas assessment project also will involve a number of Resource Geology scientists.

Computer data base systems of B.C., Alberta and Saskatchewan wells are used regularly and increasingly to produce subsurface maps, obtain data on cores, and select areas most fruitful for particular subsurface studies.

Geophysics

Geophysical activities in 1987-88 focussed on the completion of the study of the Mesozoic-Cenozoic portion of the Frontier Geoscience Project deep seismic reflection transect on the Mackenzie Delta. A .12 km thick ?Jurassic-Tertiary basin fill succession beneath Richards Island has been imaged. These data are being used to help constrain interpretations of the crustal seismic refraction data collected from the Mackenzie Delta – Beaufort Sea – northern Yukon area in March 1987. There is evidence in the crustal velocity structure that the southern part of the Mackenzie Delta is underlain by a ?Proterozoic-early Paleozoic continental margin. Gravity and aeromagnetic data are also being incorporated into these interpretations (see also Regional Geology Subdivision section). Preliminary presentations on this work were made at the American Geophysical Union meeting in San Francisco.

Interpretation of the seismic refraction data from the Peace River Arch area acquired in 1985 was completed, primarily through contracts with the University of British Columbia. The results suggest the presence of a local crustal signature for the Peace River Arch and, hence, that its origins and evolution may be related to a localized, anomalous, thermal history. Some of the results have been submitted for publication.

Collection and analysis of thermal data in the basins of western Canada was continued under contract by the University of Alberta and Tempest Geophysics. During 1987/88 the emphasis was on the Mackenzie-Beaufort area and the Sverdrup Basin (see also Regional Geology Subdivision section). Results from the Mackenzie-Beaufort area show low heat flow from the platform areas and from the Rapid Depression and Kugmallit Trough, and higher heat flows in the folded terranes of the Ogilvie Mountains and northeast of Aklavik, within the Mackenzie Delta. The variations may result from differences in basement heat flux, non-uniform thermal conductivities, or from transient fluid-flow effects.

Subsidence modelling work continued with one principal finding being that the incorporation, into thermal subsidence models, of the latent heat of crystallization of a partially-molten asthenosphere beneath a thinned lithosphere can significantly lengthen the thermal subsidence phase of basins.

In 1987-88 the Section gained a heat flow specialist, A.M. Jessop, who moved to ISPG from Ottawa, where he had been head of the Geothermal Group of the Dominion Observatory – Earth Physics Branch for more than two decades. He is coordinating the heat flow contract studies, as required under the ISPG mandate. Our basin modelling strengths were enhanced with the arrival of a post-doctorate fellow from Dalhousie University, who will be working on regional subsidence and related problems of the Beaufort-Mackenzie Basin and Peace River Arch projects.

Geochemistry

As members of the national centre for organic geochemistry within the Geological Survey of Canada, Geochemistry Section personnel continued to be active on a wide range of projects in many sedimentary basins in Canada. Source rock evaluations, oil-oil and oil-source correlations are in progress on materials from the Arctic Islands, Beaufort-Mackenzie Basin, Norman Wells area, Pine Point region, Jeanne d'Arc Basin of the Atlantic Continental Margin, and Queen Charlotte Basin of the Pacific Continental Margin, as well as Williston Basin, Saskatchewan. In addition, studies continued on the oil sands/heavy oils of Alberta and Saskatchewan, and systematic acquisition and analysis of conventional oils for the Alberta and B.C. subsurface began. More than 170 conventional oils have been acquired and analyzed to provide the in-house data base required for Western Canada Basin studies.

Preliminary results of the analysis of oil seep samples from Queen Charlotte Islands were presented at an international geochemical conference in Italy and at a Vancouver review meeting. Three separate source rocks appear to have been effective and one location on Graham Island may represent an exhumed oil field.

A GC-MS-MS (triple sector mass spectrometer coupled to a capillary gas chromatograph) was installed and used to provide detailed biological marker (chemical fossil) distribution information. Extensive work has been done on crude oils and potential source rocks from the Jeanne d'Arc Basin. These oils contain exceedingly complex mixtures of steranes due to the presence of a large number of 4-methylsteranes, thought to be derived from dinoflagellates.

Preliminary interpretation of thermal maturation results in the Mackenzie Corridor has indicated the presence of a signficant geothermal 'boundary' (fault, heat flow anomaly) in the Root Basin – Keele Arch area. Rock-Eval/TOC results from 10 wells from Eagle Plain were released in the form of an Open File Report.

The systematic geochemical characterization of the Beaufort-Mackenzie Basin continued with the publication of source potential results for additional stratigraphic units and the acquisition of additional data from the Richards Formation (Eocene), part of which is interpreted to be the source of much of the Tertiary oil in the basin.

Biomarker characterization of a large number of Western Canada Basin heavy oils and tar sand samples, from Canada's largest non-conventional oil resource, continued. These studies demonstrate that once the effects of biodegradation are discounted, most of these materials are strikingly similar in composition, with the possible exception of some of the Paleozoic, carbonate trend samples.

Collaborative work with organic petrographers of ISPG's Coal Geology Subdivision led to the first petrologically documented Canadian occurrence of an algal genus known to be important in high quality Lower Paleozoic source rocks. This is *Gloecapsomorpha*, and has been found in Ordovician rocks in Saskatchewan and Newfoundland.

Personnel Notes

The Petroleum Geology Subdivision currently employs a staff of 16 scientists, 8 technicians and a secretary. One of these scientists, geologist A.P. Hamblin, is on education leave completing a PhD at the University of Ottawa.

In September of 1987, Dr. Alan Jessop, formerly of the Earth Physics Branch, moved to ISPG to continue work on aspects of heat flow in sedimentary basins. In January of 1988, Dr. Dale Issler joined ISPG as a post-doctorate fellow, following completion of his PhD at Dalhousie University. Dr. Issler will be working on studies of subsidence models, as well as thermal and maturation history models of the Beaufort-Mackenzie Basin, and on similar aspects of the Peace River Arch study.

As of April 1, 1988, Dr. Paul Brooks was promoted from RES-2 to RES-3.

A research scientist position in inorganic geochemistry, a replacement for Dr. A.E. Foscolos who retired in 1986, should be filled early in fiscal year 1988-89. Dr. Foscolos returned to ISPG in the summer of 1987 to work toward completion of various projects.

Mrs. Kai Flexhaug has been working in a term position in the organic geochemistry extracts laboratory, and Paul Pheby is acting as a technician and draftsperson for the subdivision, also in a term position.

Many subdivision scientists are serving as Scientific Authorities and/or advisors on a large number of research and support contracts made possible through the Frontier Geoscience Program and the Petroleum Energy Research and Development Program.

Organic Geochemistry Laboratories

Extraction and Separation of hydrocarbon fractions:

	86/87	87/88
Extractions	232	418
Distillations	170	241
Separations	422	674
Gas Chromatographic Analysis	633	824
High Pressure Experiments	20	15

Source Oil Correlation Studies:

	86/87	87/88
Gasoline Range	349	148
Capillary GC/MS Analysis	520	947

Pyrolysis:

	86/87	87/88
Rock-Eval/TOC	16,511	18,819
Pyrolysis Gas Chromatography	120	25

SEM Lab Statistics

	86/87	87/88
Exposures:		1066
Paleontology Subdivision	150	
Petroleum	150	
Regional	40	
Coal	50	
Others (Machine Shop, NEB, etc.)	750	100

Inorganic Geochemistry

	86/87	87/88
XRD Mineral Determinations	13,756	8,450
XRF Analysis	13,490	14,985
Infra-Red Analysis	50	30
TGA/DTA	1,000	1,200
Atomic Absorption Analysis	78 (700)	557 (1,792)
Low Temperature Ash	150 (152)	132 (132)
CHN	325 (1,111)	
Proximate Analysis	150	10
Miscellaneous (C, P, S, Moisture, pH, Digestions, Kerogens, Extractions)	1,800	1,246 (2,780)

*No. of Samples (No. of Analyses)

COAL GEOLOGY SUBDIVISION

G. Grant Smith

The role of the Coal Geology Subdivision is to provide comprehensive geological knowledge, technology and expertise pertaining to Canada's coal resources; to determine their geological distribution, origin and potential abundance to facilitate exploration, land-use planning and policy formation; and to provide understanding of characteristics of the nation's coals in terms relevant to their commercial use in a national and international context.

The broad objective of the Subdivision is to develop and maintain a capability for providing authoritative advice to senior Department officials and to scientists in government and industry on Canada's coal resources. To achieve this, the Subdivision is organized in the three sections that relate to the nature of specialized studies being conducted.

The Coal Resource Section studies the geological framework and character of Canada's coal deposits, addressing factors that controlled areal extent, thickness variability, lateral continuity, structural geometry and fabric of coal beds. Results from these studies are essential when considering coal exploration and mining.

The Organic Petrology Section studies the character (composition and properties) of coals in Canada, providing information that is essential for assessing coals as potential feedstocks for conventional and nonconventional uses.

The Technology Development Section advances coal geoscience technologies to allow more efficient resolution of geological problems than would otherwise be possible. Computer modelling techniques, multivariate analyses (geomathematics), and microscopy techniques are examples of technologies being developed or advanced in support of other coal geoscience research.

Research by the Subdivision considers coal both as a resource having the potential to contribute wealth to the nation, and as a unique sedimentary facies providing information on the development and evolution of Canada's sedimentary basins. The occurrence and character of coal and dispersed organic matter can be a particularly sensitive indicator of syndepositional geographic and ecological conditions, and postdepositional basin subsidence and geothermal conditions.

In addition to the Subdivision's personnel, national coal geoscience activities draw on specialists in various geoscience subdisciplines from all other subdivisions at ISPG. Regional geologists, paleontologists, petroleum geologists, geochemists and computer specialists are among those who actively collaborate with scientists of the Coal Geology Subdivision.

Highlights

Highlights of the Subdivision's activities during 1987/88, including major accomplishments, advances and discoveries are as follows:

1. A presentation on the distribution and character of coal in Canada was given to the Standing Senate Committee on Energy and Natural Resources.

2. A comprehensive compendium on coal resources in Canada ("Black Book") was completed (in press), providing an up-to-date summary of the widespread distribution and diverse character of the nation's coals.

3. Estimated coal resource quantities in Canada were synthesized according to unified national standards from information provided mainly by provincial governments. New estimates, representing the first major revision to EMR official estimates since 1979, are now being used by Mineral Policy Sector, CANMET, NEB and The Coal Association of Canada.

4. "A standardized coal resource/reserve reporting system for Canada" was completed in collaboration with The Coal Association of Canada. These standards will help to maximize the consistency of resource and reserve quantity estimates reported for coal deposits in Canada, to provide a reliable, objective framework for public and commercial planning.

5. An "Independent Review Committee" of the GSC/ISPG Coal Program was established, comprising representatives of major coal companies, universities, and agencies of major coal producing provinces and the Federal Government. The Committee is asked to advise on coal geoscience priorities in Canada and on immediate, intermediate and long term goals for GSC's coal research.

6. Minor and trace element concentrations can affect the potential utility of coals. Continuing studies of the distribution of 57 elements in Canadian coals has led to major advances in understanding the causes of enrichment and depletion of some elements in different coals. For example, platinum enrichment in some coals in the interior of British Columbia has been related to flow, along faults, of platinum-rich fluids from adjacent rocks, indicating the possible presence of nearby orebodies. Concentrations of rare earth elements appear to be significantly controlled by weathering and acidity of the coal-bearing strata. Trace elements in Saskatchewan lignites are generally depleted (i.e. below Earth's crust averages), with the notable exceptions of boron and selenium, which are enriched.

7. Computer programs were developed to allow rapid display of lithological variations within and between coal seams and marker units. Cross section displays illustrating these variations previously were very time consuming to generate, and did not have the level of integrity provided by this software.

8. A GSC-developed computer program was used to provide predictions of the outcome of a 91 hole drilling program conducted by Esso Resources Canada Ltd. As a result Esso substantially modified their program and realized significant cost saving.

9. A database retrieval program was developed to extract a wide variety of information from databases of exploration information in complexly-deformed coalfields. This program is an integral part of a modelling system being developed to analyse deformed coalfields.

10. Developments in automated image analysis technology for coal petrography are reducing substantially the previously required manual effort, and are resulting in much greater productivity in analysis of coal samples. The direct capture of data in computer-processable form allows integrated statistical analyses to assist the interpretation of results.

11. A comprehensive geological model of the commercially important Judy Creek Coalfield (Esso Resources Canada Ltd. and TransAlta Utilities Corp.) in north-central Alberta was established. Analyses of the coal deposits in this coalfield assist assessment of coal potential in the less explored Upper Cretaceous Wapiti Group in northwestern Alberta.

12. Establishment and analysis of a geological model of the commercially important Battle River Coalfield (Luscar Ltd., Manalta Coal Ltd., Alberta Power Ltd., etc.) of central Alberta was completed. Petrographic analyses indicate a uniform character of coal, high in huminite content, in the various seams.

13. Fieldwork in Hoidahl Dome area, northern Yukon, confirmed the presence of high rank coals in the Kayak Formation over a distance of 4 km. The coals are both semianthracite and anthracite in rank, with low ash and sulphur contents.

14. The geological framework of the Tertiary Fossil Forest, eastern Axel Heiberg Island, was established as the basis for other studies in a continuing multidisciplinary project.

15. Coal development in Upper Cretaceous and Tertiary strata of the southern Cordilleran foreland basin, western Alberta, ranges between extremely prolific (e.g. Coal Valley/Coalspur area) to nearly absent (e.g. Porcupine Hills). Previous work attributed variations in coal development to significant climate differences (i.e. humid versus arid) in different parts of the basin. Recent work has recognized the added control on coal distribution by tectonomagmatic events in the source areas of the foreland basin. These events controlled paleodrainage patterns and other depositional conditions to which coal formation is sensitive. New paleoenvironmental interpretations will contribute to more efficient coal exploration.

16. The application of infrared spectroscopy has been extended to the classification of kerogen types and evaluation of source rock and oil shale potential.

17. The composition of coals in the commercially significant Gates Formation of northeastern B.C. and northwestern Alberta has been related to the sedimentology of the coal measures. Knowledge of the origin of the coal (forest swamp environment) and related depositional conditions (strandplain setting) provides the basis for considering and predicting variations in coal quality.

18. Several advanced computer-based geomathematical systems were developed and/or expanded (e.g. SPIDERGRAM, DENDOGRAPH, etc.) for multivariate analyses of coal variables, such as trace element content. These systems are providing insight into coal composition and causes of variations (processes), previously unattainable because of the interaction of a large number of variables. Many sophisticated systems are developed for use on a personal computer, which allows a high level of portability and easy transfer of technology.

19. The Joint Technical Meeting of the Canada/Japan Coal Liquefaction Co-operation (October 1987) recognized the critical role of geological factors in determining coal feedstock characteristics. Participation by GSC coal geoscientists provided the opportunity to demonstrate the scope of the Subdivision's capabilities and its recent developments in characterizing Canadian coals in terms that are relevant to emerging coal utilization technologies.

20. The Subdivision provided major input on Canada's coal resources to The Coal Association of Canada and Mineral Policy Sector for their presentations to "Energy Options" hearings.

21. General reconnaissance of coal occurrences in northern British Columbia and Alberta and southern Yukon was completed in support of future program planning. A few examples of areas visited having deposits of potential commercial significance for which future studies are indicated include Bowron River, Telkwa (Skeena Basin), Mount Klappan (Bowser Basin), Whitehorse (Whitehorse Trough), Burwash Landing (St. Elias Trough), and Grande Cache (Wapiti Group).

Personnel Notes

The Coal Geology Subdivision has a permanent staff of 10 scientists, 3 technicians and 1 secretary. The resignation of Coal Geologist C.B. Wrightson, in May 1987, caused a vacancy that continued through year-end (March 31, 1988). A new position of Senior Organic Petrology Technician was created to assist the preparation and analysis of a growing backlog of samples. K.C. Pratt was promoted to this new position in July 1987, and M. Tomica was hired as Organic Petrology Technician in March 1988. The transfer of D.W. Gibson to the Regional Geology Subdivision (to pursue studies of the Triassic in western Canada) has reduced the Coal Geology Subdivision's staff from 11 to 10 scientists.

Visiting Professor Li Baofang, from the People's Republic of China, completed an 18 month study of the Judy Creek Coalfield, Alberta, and returned to China in October.

Dr. T. Jerzykiewicz was recently appointed Adjunct Research Scientist to the Tyrrell Museum of Paleontology. He will take part in the Canada-China Dinosaur Project undertaken by the Tyrrell Museum in co-operation with the National Museum of Natural Science (Ottawa), the Institute of Vertebrate Paleontology and Paleoanthropology (Beijing, China) and the Ex Terra Foundation (Edmonton). Dr. Jerzykiewicz will take part as a sedimentologist on the Canada-China Expedition to Inner Mongolia in 1988.

Dr. F. Goodarzi acted as Adjunct Professor of Geology, universities of Regina and Waterloo. He also acted as United Nations (UNDP) advisor on coal petrology and technology.

Organic Petrology Laboratory

The workload of the Organic Petrology Laboratory continued to increase over previous years. 2026 samples were prepared of coal, kerogen, sedimentary rocks and other specialized organic materials representing an increase of almost 20% over the previous year. Approximately 35 oriented blocks of coal were also prepared. Subsequent analysis by staff, contract personnel and students was performed on the majority of these samples. 950 samples were sent to outside laboratories for chemical analysis and 600 for trace element analysis. Some 1000 data entries were made on the ORGANIC PETROLOGY DATABASE by laboratory staff. Purchase of state of the art laboratory equipment should facilitate sample preparation in the coming year, freeing full time staff to perform more advanced work.

PETROLEUM RESOURCE APPRAISAL SECRETARIAT

R.M. Procter

The Secretariat, which is a small staff group within ISPG, was created early in 1980. The Secretariat's major responsibility is for the preparation of estimates of Canada's potential oil and gas resources, including the provision and testing of methodology, convening of evaluation meetings, final responsibility for estimates and preparation of reports. The Secretariat provides functional direction to the GSC petroleum resource evaluation activities at ISPG and AGC and liaison with geologists and geophysicists of the Canada Oil and Gas Lands Administration (COGLA).

The results of resource evaluation work done by GSC are communicated to a Petroleum Resource Appraisal Panel, chaired by the ADM, Petroleum and consisting of ADM's in Energy, Science and Technology, plus representatives from INA and NEB. Panel meetings are held periodically to review specific resource base topics, to identify priorities in evaluations, and to discuss oil and gas resource activity in general.

The Secretariat has a liaison role with petroleum exploration companies, other federal agencies, provincial government agencies, and universities as well as duties of a consultative nature with respect to international petroleum assessment matters.

Sedimentary basin syntheses and regional resource geological syntheses as they relate to petroleum geology and resource evaluations are undertaken by the Secretariat for the GSC.

An additional role of the Secretariat is the curation of all resource estimate data and files as well as provision of data to downstream cost and supply analysis groups.

Highlights

1) Activities related to evaluation of oil and gas were intensive throughout the year and focussed on: production of final typeset text, in English and in French, of GSC Paper 87-26 "Conventional Oil Resources of Western Canada"; the provision of new estimates for the Jeanne d'Arc Basin and for the Mackenzie Delta-Beaufort Sea region; and preliminary preparation of oil and gas resource estimates associated with disputed boundary areas (Canada-France; Alaska-Canada Juan de Fuca area).

2) On the international scene, Secretariat staff participated in a UN expert mission in cooperation with CCOP, through southeast Asia (G.C. Taylor); a resource evaluation seminar for seven South American countries in connection with the PCIAC sub-Andean petroleum potential project (R.M. Procter and G.C. Taylor); and in a research symposium on resource evaluation methods held at Loen, Norway, sponsored by IUGS (P.J. Lee and R.M. Procter). Staff also participated in several reviews to both domestic and international oil companies.

3) N.J. McMillan played a prominent role in the organization of the very successful Second International Symposium on the Devonian System held in Calgary, August, 1987. He is also Chief Editor of the proceedings of that conference, which include more than 150 papers that will appear in a CSPG Memoir to be entitled "Devonian of the World".

Personnel

The Secretariat currently consists of an Executive Director, three scientists, an analyst and a secretary:

Foo, A.G.	Secretary
Lee, P.J.	Senior Geologist - Resource Evaluation Methodology

McMillan, N.J.	Senior Petroleum Scientist - Basin Studies
Price, P.R.	Petroleum Resource Technical Analyst
Procter, R.M.	Executive Director
Taylor, G.C.	Senior Petroleum Geologist

Computer Modeling Group, nonprofit Alberta company, Director.

GEOLOGICAL PUBLICATIONS SUBDIVISION

N.C. Ollerenshaw

This subdivision is responsible for ensuring that publications resulting from the Institute's scientific programs meet accepted high standards. This is achieved mainly through the screening and processing of manuscripts for publication in the Geological Survey's own series of papers, bulletins and memoirs, and in established national and international scientific and technical journals. Items of immediate interest, requiring rapid publication, are made available through an Open File system. In support of this objective, the Subdivision maintains capabilities and facilities in scientific editing, cartography, technical photography, word processing and phototypesetting. In addition, the Subdivision maintains a large inventory of, and operates as a retail outlet for, all Geological Survey papers, bulletins, memoirs and geological maps, and departmental topographic maps for Western Canada and the Canadian Arctic. The Subdivision communicates with the scientific community and the public by responding to direct requests for information, by preparing semi-popular articles and displays, by sending news reports to technical and scientific journals and newsletters, by lectures, and by participating in the work of committees and associations.

During the past year, the editorial staff processed 33 reports, 4 maps, 63 outside papers, 64 abstracts, and 22 open file reports. Processing of manuscripts involves the selection of critical readers and the evaluation of their reports, scientific editing, copy editing, proofreading and, in the case of GSC reports, the layout of the publication.

Most maps and illustrations produced by Institute scientists for publication are prepared in the Cartography Section. To expedite publication, some are now prepared by the scientists themselves with the advice and guidance of Cartography Section staff. The work of the Section includes both black-and-white and multicoloured illustrations in addition to photomechanical and reproduction work. The Section also prepares slides for oral presentations and large graphic displays for workshops, meetings, and for information exchanges with universities. Good contacts are maintained with the local university and technical institute, lectures are given and students receive guided tours through our cartographic facilities as part of their course work.

The Photographic Section provides general and specialized photographic services for the Institute staff. Preparation of paleontological plates is possibly its most demanding and unique function. This entails photographing fossils from various key angles and, together with microphotography, involves about 40 per cent of the Section's effort. The production of colour negatives and prints increased substantially during this fiscal year. Copy work accounts for close to 50 per cent of staff time. Miscellaneous activities include I.D. and passport photography, specialized photographic work for some other Government departments, and an increasing amount of publicity work illustrating personnel and equipment in action.

The Word Processing Centre produces all the Institute's manuscript copy for scientific papers, ranging from initial drafts to final, camera-ready and/or typset pages for the printer. This year, some 48,000 pages were processed. In addition, some 1100 letters and memoranda were typed as a special service. ISPG uses a network of 14 Xerox workstations and two microcomputers to process and transfer both copy and data. A Compugraphic typesetter was used in-house to produce, in English and in French, the widely anticipated, "Conventional Oil Resources of Western Canada" (GSC Paper 87-26, J.A. Podruski et al.).

The Institute's Publications and Air Photo Section, the largest retail operation of its kind in Western Canada, reported increases in sales during the fiscal year (as the graphs at the conclusion of this report illustrate). Inventory and sales data are currently being kept on computer files. Credit card purchases of GSC publications may now be made with Mastercard and Visa.

Personnel Notes

Tasneem Fazel resigned as Switchboard Receptionist, February 19, 1988 and was promoted to a CR-03 position in Accounts.

Maureen Hill joined the Word Processing Centre as a Word Processing Operator (term) on October 28, 1987.

Donna Henry joined the Word Processing Centre as a Word Processing Operator (term) on March 22, 1988.

STATISTICS ON SUBDIVISION ACTIVITIES
(April 1, 1987 — March 31, 1988)

Scientific Editor's Office

Format	Received	Edited/ Approved	To Ottawa or Publisher	Printed
Memoirs	0	1	0	2
Bulletins	6	9	6	6
Papers	6	5	1	3
88-1	19	18	18	18
Maps	5	4	0	3
Open Files	18	22	18	12
Outside				
Papers	57	63	63	45
Abstracts	66	64	65	44
Total	**177**	**186**	**171**	**133**

Word Processing Centre

Letters	1,100
Memos	429
Tables	1,918
Blueline pages	16,085
8 1/2 x 11 pages	12,599
8 1/2 x 14 pages	3,604
Miscellaneous items	2,228

Compugraphic (Typesetting)

Paper (8 1/2" x 11")	15,744
Film (8 1/2" x 11")	2,159

Geological Cartography Section

Maps and figures completed by the Cartography Section between April 1, 1987 and March 31, 1988.

	1986-1987	1987-1988
Multicolour maps and section sheets	7	1
Figure illustrations (page)	346	804
Figure illustrations (pocket)	0	1
Preliminary maps	0	8

Manuscripts received	1986-1987	1987-1988
Multicolour geological maps	1	5
Figure illustrations (page)	438	650
Figure illustrations (pocket)	1	18

Maps and illustrations in progress on March 31

	1986-1987	1987-1988
Multicolour geological maps	3	2
Figure illustrations (page)	209	221
Figure illustrations (pocket)	1	0

Miscellaneous drafting which averaged approximately 20% of the total drafting time comprised 2483 separate items of which 321 were slides.

Reproduction services	1986-1987	1987-1988
Diazo prints	4,441	5,512
Diazo prints (frame shots)	272	406
Di-chrome	482	313

Photomechanical services		
Film (sheets, negatives and positives)	4,242	5,184
Drafting keys on scribecoat	168	101
Blueline on Cronaflex	11	20
Colour proofs	23	37
Peelcoats	112	107
KC-5 prints	2,748	3,720
Autopositives (multiple exposure)	713	465
Sepia (dry erasable film)	112	193

Camera	services
Film	shots (line)
Film	shots (halftone)
Paper	206
Ektaflex	32

Photography Section

Production during the review years 1986-87 and 1987-88

	1986-1987	1987-1988
Total number of black and white, continuous tone 4" x 5" negatives	1,245	1,092
Total number of black and white prints	10,015	11,687
Total number of contact proof sheets	1,288	1,210
Total number of 35 mm films (black and white and colour) submitted for processing by staff members	239	465
Total number of black and white 35 mm negative films	226	189
Total number of 35 mm colour slide films	276	296
Total number of colour negatives on file	2,138	5,088
Total number of colour prints	3,881	6,575

Publications and Airphoto Section

Breakdown of Sales

	1986-1987	1987-1988
Surveys and Mapping	$ 87,356.00	$ 85,322.20
National Air Photo Library	15,829.18	21,033.13
GSC Maps	17,172.12	20,980.50
Rock and Mineral Kits	2,144.00	1,420.00
Miscellaneous GSC Material	1,022.60	789.85
GSC Publications	14,010.30	12,328.35
Mineral Policy Sector	322.45	154.50
TOTAL SALES	$ 137,856.65	$142,028.53

Breakdown of Accounts

	1986-1987	1987-1988
Credit Sales	$ 56,259.00	$ 69,102.25
Cash Sales	$ 77,815.85	$ 75,748.03
Received On Account	$ 60,040.80	$ 66,280.50

Air Photos

A total of 199 order were forwarded to Ottawa during the year. These consisted of:

Items Ordered	Quantity	Price	Value
B & W Contact prints	4,969	$ 3.50	$ 17,391.50
Colour contact prints, negative originals	26	8.50	221.00
Black and white enlargements 30 x 30 full image	32	41.00	1,312.00
Black and white enlargements 40 x 40 full image	33	46.50	1,534.50
Black and white enlargements 10 x 10 part image	6	18.75	112.50
Black and white enlargements 15 x 15 part image	9	25.00	225.00
Black and white enlargements 20 x 20 part image	4	31.25	125.00
Black and white enlargements 30 x 30 part image	1	51.25	51.25
Black and white enlargements 40 x 40 part image	1	58.00	58.00
Black and white diapositives	50	8.50	425.00
Flight line index maps	24	1.75	42.00
Lansat quad mosaics	2	28.00	56.00
Total	5,157		$ 21,553.75

DATA MANAGEMENT SECTION

Ken N. Nairn

The Data Management Section provides computer facilities and support to all subdivisions within the Institute with a permanent staff of 3 analysts and 1 additional analyst seconded to the group. There are over 70 personal computers in the building as well as 40 terminals connected to the central facility (based on a Hewlett Packard 3000 Series 950 computer) which provides laser printing, plotting, processing and file storage services.

This year the Central Processor (CPU) was upgraded within the HP3000 product line to a Series 950 model. The replaced Series 70 CPU was sent to the GSC GEOSCAN data centre in Ottawa to upgrade their processing capability. The changeover here has netted a 400% increase in processing capacity. In order to fully realize the speedup, all software must be converted and recompiled. This process is expected to require at least one man-year of Data Management time.

The Well Database System has been extended to include Saskatchewan, British Columbia, Arctic and east coast wells. The system is used by project geologists as well as those undertaking structural studies to locate wells with cores in formations of interest. The well data for Canada Lands was returned to COGLA in a sanitized version for comparison with a well database under construction there.

A major effort was undertaken to extend the analytical capability of the X-ray Flourescence and Spectrometry system in the Clay Minerology labs. A. Heinrich and D. Lepard collaborated to provide further analysis of trace element concentrations, and calculation of mass absorption coefficients.

In collaboration with the Coal Subdivision, work was initiated under contract to upgrade analytic capabilities with respect to deformed coal deposits. The systems developed provide a framework for further modelling initiatives in the deformed coal belt. Cross-section program software was enhanced to provide different fill patterns for the various lithologies encountered. The resulting displays are suitable for publication or slide/overhead display.

Personnel Notes

K. Mottershead returned from maternity leave. A large list of modifications awaited her return. Her responsiblities have been extended to include MINISIS support to the Library and Curation, and a data inventory project on thermal maturity.

W. Pickering joined the staff in January, undertaking responsibilities in support of the burgeoning micro population and the divergent lab systems.

POLAR CONTINENTAL SHELF PROJECT

Introduction

The Polar Continental Shelf Project (PCSP) coordinates scientific studies in the Canadian Arctic and provides vital logistical support and advice to research groups working in the Arctic Islands, the northern mainland, and on the Arctic Ocean. The PCSP works closely with other branches of Energy, Mines and Resources Canada and also cooperates with other government departments and agencies, and with university groups in providing expertise, logistical facilities, and transport in support of their studies. The Polar Shelf keeps both the scientific community and northern residents informed of ongoing scientific projects. The interagency, multidisciplinary character of the PCSP is instrumental in fostering effective, physically safe, and economical scientific development of the Canadian Arctic. The scientific activities of the several Federal departments and Canadian universities provide needed information for the exercising of Canada's sovereignty over its Arctic regions and in its ability to assert leadership as a polar country.

The Polar Shelf maintains base camps at Tuktoyaktuk in the Mackenzie Delta region, at Resolute on Cornwallis Island, and on the "ice island", also known as Hobson's Choice ice island, in the Arctic Ocean. Fieldwork is supported from these camps, generally between mid-February and late September. Headquarters for the Polar Shelf is in Ottawa.

Highlights

Logistical support was provided to 232 field parties in the Canadian Arctic in 1987; this number included 62 university groups and about 15 foreign agencies. The 1987 field operation was the largest in the history of the Polar Shelf.

Geological mapping projects were supported in the Richardson Mountains, on Prince Patrick Island, on Boothia Peninsula, and on northwest Devon Island. Reflection seismic profiling in the marine channels of the Sverdrup Islands was based on Lougheed Island.

A concerted study of the recently-discovered 'fossil forest' on Axel Heiberg included the disciplines of paleobotany, and soil science. A film team obtained material for a film or video documentary, now in preparation, and National Museum people investigated the locality for possible protection as a heritage site.

Studies supported in the Beaufort Sea region included physical and chemical oceanography, shoreline studies, the biology of shorebirds, and the physics of sea ice around drilling platforms. Marine wildlife studies in the Lancaster Sound region were carried out in preparation for possible designation of the Sound as a marine national park.

The National Park Reserve of northern Ellesmere Island was investigated by park wardens and others for an assessment phase in preparation for establishment of a national park.

The base camp on the Ice Island was occupied between March 3 and the end of August 1987. Marine geological, geophysical, and oceanographic

investigations of the continental shelf north of Meighen Island were conducted, and the Island's irregular movement along the borders of the Arctic Ocean was continuously tracked using satellite navigation.

A new warehouse and laboratory building was completed at Tuktoyaktuk; also the living quarters were upgraded for improved safety and efficiency.

Plans and designs for a new building at the PCSP base at Resolute were completed.

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(to March 31, 1988, as supplied by reporting units)

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