CANADIAN GEOSCIENCE COUNCIL

EARTH SCIENCES IN THE SERVICE OF THE NATION

A REPORT ON THE GEOLOGICAL SURVEY OF CANADA

Published for the Council by the Geological Survey of Canada as Paper 89-25

EARTH SCIENCES IN THE SERVICE OF THE NATION

A REPORT ON

THE GEOLOGICAL SURVEY OF CANADA

CANADA'S NATIONAL EARTH SCIENCE AGENCY

A Forward-Looking Review of the Role of the Geological Survey of Canada in the Context of the Canadian Nation

By

THE CANADIAN GEOSCIENCE COUNCIL

May 1989

Available in Canada through

authorized bookstore agents and other bookstores

or by mail from

Canadian Government Publishing Centre
Supply and Services Canada
Ottawa, Canada K1A 0S9

and from

Geological Survey of Canada offices:

601 Booth Street
Ottawa, Canada K1A 0E8

3303-33rd Street N.W.,
Calgary, Alberta T2L 2A7

100 West Pender Street,
Vancouver, B.C. V6B 1R8

A deposit copy of this publication is also available for reference
in public libraries across Canada

Cat. No. M44-89/25
ISBN 0-660-55557-3

Price subject to change without notice

Table of Contents

SUMMARY

The Canadian Geoscience Council, in its role as a reviewer of Canada's Earth Science programs and policies, decided to undertake a forward-looking review of the overall function and role of the Geological Survey of Canada. A committee of experienced earth scientists and professionals drawn from outside the Council and the Survey was struck for the purpose. This is a report of their findings.

The GSC has long established a respected position of leadership and achievement in traditional geoscience. Its principal activities have been and will continue to be related mainly to the energy and minerals industries but times and technologies change, as does knowledge and our understanding of it.

Current environmental changes on the surface of the planet are a source of major concerns for humanity. Public awareness and concern are increasing rapidly. The breadth and complexity of these problems demands sophisticated investigation and understanding across the entire range of earth sciences. The need is to modify and adapt our practices and activities in harmony with our changing needs and our environment.

Geological mapping, in its most comprehensive form, remains the primary mission and mandate of the Survey, but the definition needs to be expanded, with increasing attention directed to other earth science disciplines.

There is a need for the compilation and integration of data generated by federal and provincial agencies, the private sector, and academia. The GSC is superbly suited to gather and consolidate all such essential geologically-related information and to provide the appropriate access and distribution systems.

Hydrogeology and associated ground-water studies are an integral part of earth systems science. Water is fully interactive with the solid Earth and both are fundamentally related to pollution and environmental quality. The strong GSC coverage of the surficial geological domain should be augmented by comprehensive hydrogeological studies and research.

In Canada, there have been essentially no organized studies of the interaction between public health and the Earth. Participation in this rapidly growing scientific domain is a national need. It requires a broad and integrated application of earth systems science interfaces with pollution, public health and land-use activities. The multi-disciplinary nature of studies in this little investigated domain makes the GSC an ideal candidate for leadership.

The Committee finds the GSC to be recognized and appreciated by the international scientific community (perhaps more so than at home) for the excellent quality of its work and products, even though many GSC international activities lack official status. These activities should be given formal status and continued in a manner to maximize Canada's benefits from participation in the international geoscience community and to enhance the nation's existing prestige and leadership.

The Committee finds that GSC expertise in the earth sciences is under-utilized in areas of international government activity, such as foreign aid, and that inadequate procedures exist for consultation with an input from the GSC.

The interests of the provinces in having a federal presence in their territorial jurisdictions vary greatly from one province to another, often in proportion to provincial self-sufficiency in the geosciences. The GSC has had, and will likely continue to have, a complementary role to those of the provinces, particularly in the petroleum and mineral sectors.

The GSC is the ideal organization to address all aspects of earth systems science that affect Canada. Its leadership should continue with an expanded mandate, but the current organizational structure may not be the one most appropriate to fully serve the nation and perhaps should be reassessed.

RECOMMENDATIONS

1. *That the Geological Survey of Canada be designated as Canada's National Earth Science Agency, with a mandate broadened to include comprehensive investigation, assessment and monitoring of all aspects of Earth System Science as these relate to Canada.*

2. *That the GSC expand its scope of mapping activities to determine the causes and effects of the geological phenomena that contribute to or are affected by Global Change, define the risks and deterioration arising from them, and to research remedies and solutions for the problems.*

3. *The prime activity of the GSC should continue to be the geoscience mapping of Canada, and it should remain an in-house function.*

4. *Although the primary mission of the GSC continues to be mapping, the definition of mapping should be expanded explicitly to include the subsurface and offshore.*

5. *The GSC should consolidate its Arctic expertise in two places: Arctic Ocean Islands and margins at ISPG, because of the expertise already there, and studies of the Arctic Ocean at AGC for the same reason.*

6. *The creation of a modern computerized database system that incorporates all relevant existing data should be one of the highest priorities of the GSC, in collaboration with the provincial surveys and industry.*

7. *That the GSC develop its capabilities and competence in digital and computer-based information processing and evaluation technologies to exploit adequately the information contained in the national database, and to meet the needs of industry, government and academia.*

8. *The GSC should become fully active in integrated investigation and assessment of surficial geology and hydrogeology, addressing as well the interfaces of land use, climates, global change and environmental concerns such as the quantity and quality of water in the bioshpere. This should be an extension of the present active Quaternary and surficial geology function.*

9. *That a GSC Health Geoscience section be set up with links to the Department of Health and Welfare. The mandate of this unit should be to gather and assemble new and existing geoscience data pertinent to the environment, hazards, disease, waste disposal, and other aspects related to health. It should also be responsible for stimulating and coordinating research in health geoscience within the GSC, within other federal and provincial agencies, and the university community.*

10. *That the GSC legitimize and fully recognize its present international activities and the need for their expansion by increasing substantially the funding of the International Geology Office. This Office should also administer the funding for bilateral exchanges, international projects, and the seconding of Survey officers of its staff for various assignments. In due course, GSC should consider establishing a Foreign Geology Division.*

11. *That the GSC be recognized as the official advisor to all arms of Government on matters concerning international geoscience.*

12. *Individual scientists of the Survey must be encouraged to view their work in the social context and to inform the public of its significance.*

13. *The Survey should recognize lucid communication of science and other contributions to the public appreciation of science as valid elements in career advancement of scientists.*

14. *GSC should focus its activities on topics where overlap with the specific mandates of the provincial surveys are minimal.*

15. *The excellent degree of cooperation developed between the Federal and Provincial Governments through the Mineral Development Agreements (MDAs) for geoscientific surveys, should be maintained.*

16. *GSC should play a monitoring and coordinating role for the main geoscience activities carried out on the Canadian landmass and offshore by the GSC, provincial and territorial surveys, universities and institutes, mining and petroleum companies and consultants and service firms.*

1. INTRODUCTION

a. Background

During 1988 the Canada Geoscience Council (CGC) decided to undertake a forward-looking review of the overall function and role of the Geological Survey of Canada (GSC) in the context of the Canadian nation and community. This decision arose from CGC's role as a reviewer of programs and policies of the Geological Survey of Canada, of various provincial geoscience agencies and programs and as the united voice of Canadian Earth Sciences.

The objective of the study is to assist the GSC in the formulation of policy and programs and to obtain the most effective deployment of the limited resources available to it.

At the September 16, 1988 meeting of the CGC, it was decided that a committee be appointed comprising experienced scientists and professionals independent of the Council itself and of the Geological Survey, but representative of the full range of Earth Science activities in the nation. The timing was deemed most propitious in light of the recent changes in senior management personnel at the Survey. The terms of reference for the study by the Committee were as follows:

1) to assess the espoused mandate and mission of the GSC in light of its historical relevance, present realities, and projected future trends in Canadian geoscientific endeavour;

2) to ascertain which elements of GSC operations can be deemed to constitute core in-house activities essential to its mandate and to its viability as the national geoscientific institution serving the Government and people of Canada;

3) to produce perspectives on what should be the nature and level of GSC interaction with earth resource industries, the academic community, federal and provincial jurisdictions, the people of Canada and the international community; and

4) to produce a report and recommendations.

b. Membership

The Committee was assembled under the guidance of G.W. Mossop, President of the CGC. Final membership comprised:

Roy O. Lindseth (Chairman)
Teknica Resource Development Ltd.
1100 - 736 - 6th Ave. S.W.
Calgary, Alberta, T2P 3T7

Robert Y. Lamarche (Co-chairman)
Ministère de l'Énergie et des Ressources
Gouvernement du Québec
1620, boul. de l'Entente
Québec (Québec) G1S 4N6

Andrew Baillie
917 Rideau Road S.W.
Calgary, Alberta T2S 0S3

Chris Jennings
Corona Corporation
1900 - 120 Adelaide Street West
Toronto, Ontario M5H 1T1

Sandra Barr
Department of Geology
Acadia University
Wolfville, Nova Scotia B0P 1X0

Hugh Morris
Imperial Metals Corporation
800 - 601 West Hastings St.
Vancouver, B.C. V6B 5A6

Come Carbonneau
Roche Ltée
2535 Boul. Laurier
Ste. Foy, Québec G1V 4M3

Ward Neale
5108 Carney Road N.W.
Calgary, Alberta T2L 1G2

John Gammon
Mineral Development and Lands Branch
Ministry of Northern Development and Mines
880 Bay Street, 3rd Floor
Toronto, Ontario M5S 1Z8

Euan Nisbet
Department of Geological Sciences
University of Saskatchewan
Saskatoon, Saskatchewan S7N 0W0

c. Activities of the Committee

The full Committee met on three occasions: October 17 and November 23, 1988, and January 20, 1989. Subcommittee groups have met intermittently. To expedite the study, individual members reported in draft on areas relevant to their expertise, and all members were charged to submit comments and interventions on any topic of their choice. In addition, committee members were free to canvas associate and peer groups for valuable insights or data. A summary tentative draft report was prepared and presented to the December 1988 meeting of the CGC in Ottawa. At that time, some of the tentative conclusions and findings were revealed in discussion form to the management of the GSC and EMR.

It should be emphasized that the Committee has reviewed and debated the existing mandate and current objectives of the GSC. It has not conducted a review or enquiry into the detailed activities, programs and procedures of the GSC.

Conclusions and recommendations for the future mission of the Survey developed by the Committee have been made in the broadest context of global and national earth sciences in the service of the Canadian nation.

2. THE GSC – PAST AND PRESENT

a. History

The Geological Survey of Canada came into being in 1842 supported by funds set aside in 1841, and its status was confirmed by an Act of Parliament in 1845. Its original mandate was to map the then 'Province of Canada', to report properly with maps, diagrams and specimens, and to preserve this material.

During the succeeding 147 years the Survey has served our nation well, evolving and responding to trends in the earth sciences, and to the changing strategic and intellectual needs of Canadian society. Its international reputation as a national geological survey is second to none.

In response to changing times and events, the GSC has evolved and changed. These events have been well documented and will not be elaborated on here.

Today, with concerns of global change being raised in many quarters, it is appropriate that Government, the management of the Survey, and the Canadian geoscience community should assess the role of the Survey in our nation and the changes, if any, that may be needed to optimize its future. In particular, the Deputy Minister's Office and Management of the Survey must be commended for their vision of future needs and for their open attitude toward constructive changes.

b. Present Status of the GSC

The present activity level of the Survey can be summarized in the following table of salaries, operating and capital budgets for the six administrative divisions. Traditional programs and services to the Survey's long term clients – the petroleum and mineral industries, dominate. It is estimated that approximately 85% of total activity in some way relates to these activities.

GEOLOGICAL SURVEY OF CANADA SECTOR
SUMMARY OF ALLOTMENTS
1988/89
$000

	ADM	PPS	SMG	CGMR	GTS	PCSP	TOTAL
Total Salaries	167	6,560	16,938	13,860	10,007	977	48,509
Total Operating	454	3,408	16,995	9,327	9,448	5,277	44,910
Total Capital	38	585	2,421	1,507	2,245	5,931	12,727
						TOTAL	106,14

ADM: Assistant Deputy Minister
PPS: Programs, Planning & Services
SMG: Sedimentary and Marine Geoscience
CGMR: Continental Geoscience and Mineral Resources
GTS: Geophysics and Terrain Sciences
PCSP: Polar Continental Shelf Project

c. Deployment

The Survey operates principally from its headquarters in Ottawa which house the majority of staff and laboratory facilities. Regional and/or special applications centres exist at the following places:

i. The Atlantic Geoscience Centre

This office, housed at the Bedford Institute of Oceanography in Dartmouth, N.S., is responsible for providing geological information and expertise for the Atlantic and Arctic offshore areas.

ii. The Institute of Sedimentary and Petroleum Geology

This centre is in Calgary and is responsible for the study of Canada's Western and Arctic sedimentary basins which contain much of our known oil, gas and coal resources.

iii. The Cordilleran and Pacific Margin Offices

This unit comprises the Pacific Geoscience Centre at Pat Bay, and the Cordilleran office at Vancouver. The grouping provides geological and geophysical information on the mainland and offshore areas including studies of recent tectonic activities and seismic risks.

iv. The Quebec Geoscience Centre

Very recently, a new joint office has been opened at Quebec City in collaboration with the Institute National de la Recherche Scientifique (INRS).

3. THE PRESENT CONTEXT - CHANGING TIMES

"The major task of management is not to do the right thing, but to determine the right things to be done."

Peter Drucker

The past few years have been marked by a remarkable upsurge of human interest in the planet on which we live. Ecological consciousness developed in the 1960s and 1970s has now expanded into comprehensive concern over man's interaction with the Earth, including its atmosphere and oceans.

Mankind has begun to realize that a hitherto unrecognized force is now at work on the surface of the planet. In the very recent part, as a result of geometric growth in population, the human race has begun to change the environment. These global changes occur more rapidly than, and in a different manner from, those caused by established geological systems.

This leads to two forms of inquiries: "how can the planet support mankind?" and "how does mankind affect his planet?"

Responses have included programs such as the assessments of Global Change and the ever-growing popular debate on matters of serious concern such as the greenhouse effect. Serious questions have been raised about the viability of Earth ecosystems given man's present behaviour. Increasingly, society is concerned about the environment, pollution, clean air and water as well as traditional concerns relating to supplies of non-renewable resources, to natural hazards, and the replenishment of nature's own productive systems.

Our increased understanding has led to growing recognition of the intricate interdependence of different components of scientific study of the crust. We now understand that the Earth functions as an active closed system, and no change to one part can occur without causing some effect on another. The science of the solid Earth system must incorporate studies of all its components, including water, and all its processes and dynamics.

For Canada, the second largest country on the surface of the planet, these matters are of the utmost importance. Traditionally the Geological Survey has played a central role in the scientific assessment of much of Canada. It is appropriate to assess the effectiveness of its present role and the changes required for the future.

The study of Global Change and its relationship with the changing environment is incredibly complex, yet the very existence of mankind in the future may depend on it. The ability to define, separate, predict and control the effects of natural and induced hazards will determine all future activities on this planet.

The GSC, by nature of its fields of expertise, is the premier agency for preparing, coordinating and carrying out the necessary studies that governments will find essential if our planet is to survive.

RECOMMENDATIONS

1. That the Geological Survey of Canada be designated as Canada's National Earth Science Agency, with a mandate broadened to include comprehensive investigation, assessment and monitoring of all aspects of Earth System Science as these relate to Canada.

2. That the GSC expand its scope of mapping activities to determine the causes and effects of the geological phenomena that contribute to or are affected by Global Change, to define the risks and deteriorations arising from Global Change, and to research remedies and solutions for these problems.

4. CHALLENGES AND FUTURE DIRECTIONS

a. Geoscience Activities

i. Surveys, Mapping and Resource Appraisal

Mapping, namely the acquisition, interpretation, and display of earth science data, has been the single most important function of the Survey, and should remain so. The importance of mapping as a basic activity cannot be over-emphasized. Gathering, organizing and interpreting basic data are the basic tasks of scientific investigation and research.

Michael Polanyi, in his book, Personal Knowledge, states, "...all theory may be regarded as a kind of map extended over space and time". More specifically, John Ziman, the British physicist, in his book, Reliable Knowledge, states, "...the processes of real interest to geologists can scarcely be grasped except in mappable form".

Clearly the GSC has a prime responsibility and accountability to continue this function. No other body is capable of providing the required comprehensive approach and the provision of a national service with national scope of accountability. But times and technologies change, as does knowledge and our understanding of it. We need to modify and adapt our practices and activities in harmony with changing needs and the environment.

Traditionally, GSC mapping has been predominantly the record of landsurface information. However, offshore areas of the Canadian continental shelf are simply submerged extensions of the exposed landmass and must be incorporated into an overall mapping program. Similarly, surveys of remote areas such as exist in the Arctic and western mountain ranges must be fully integrated into the information available.

The past quarter century has seen a major move into subsurface mapping. This is accomplished by a combination of remote sensing of the subsurface through geophysics and direct sampling through drilling. Mapping the third dimension is a fast developing science which yields enormous volumes of data to be incorporated into the overall database and mapping process. The largest volume of this type of data is in private hands; thus collecting, coordinating, and interpreting become major tasks.

The GSC is superbly suited to gather and consolidate all essential geologically related information, including that presently residing in other agencies, and to perform the appropriate interpretation and research.

During the 1990s and on into the 21st century, geoscience mapping must be a multi-disciplinary exercise that integrates traditional techniques with a host of geophysical remote sensing probes. It should incorporate traditional geological and terrain components, but add geochemical, radiometric, gravity and magnetic potential field measurements and include air photo, radar, and satellite mapping data as important elements. Other disciplines, as varied as paleomagnetism, isotope analyses, and various forms of spectroscopy need to be used where appropriate.

The gathering and processing of specialized basic data, such as aerial surveys, seismic and potential field measurements, and computer processing of geophysical data, all require intermittent use of expensive specialized equipment and narrow expertise, and therefore are probably best contracted out.

Similarly, detailed evaluation studies, such as those done by the petroleum industry, that require special infrastructure not generally available to the GSC, may be better left to industry.

The prime GSC activity of gathering basic data and mapping should always remain an in-house function. Maintaining consistent high standards for quality control and methodology are extremely important in order to ensure a uniformly high-quality final product.

ii. Ocean Studies

The ocean floors are one of the best of the Earth's "environmental libraries". They are places where we can monitor past and present Global Change.

The ocean floors also provide sites where mineral-forming processes can be observed and monitored. Understanding of these processes can clearly help in the search for our diminishing mineral resources.

Continental margins, where oceans and continents interact, are particularly important in order to understand how our present continents and their sedimentary basins developed. In the past few years deep seismic studies have resulted in major advances in our understanding of how the solid Earth works.

In addition to the obvious potential economic results of work in the Arctic, the Arctic Ocean plays a key role in the understanding, monitoring and possible prevention or mitigation of detrimental effects from Global Change.

RECOMMENDATIONS

3. The prime activity of the GSC should continue to be the geoscience mapping of Canada, and it should remain an in-house function.

4. Although the primary mission of the GSC continues to be mapping, the definition of mapping should be expanded explicitly to include the subsurface and offshore.

5. The GSC should consolidate its Arctic expertise in two places: Arctic Ocean Islands and margins at ISPG because of the expertise already there, and studies of the Arctic Ocean at AGC for the same reason.

iii. Data and Automation

The ever-increasing volume and complexity of data and the growing array of diverse uses to which they are put, demand increasing automation of the total database.

The value of scientific information is truly achieved only when it can be used readily for widespread practical purposes as well as the building blocks for further science. Clearly there is a need for the design, development and implementation of comprehensive and user-friendly data systems.

The quantity and variety of information needed to describe and inventory the natural resource assets of Canada make a computer-assisted system essential for handling and maintaining a complete, accurate and current archive. A well-organized well-managed database facilitates data integration and analysis, enhances accessibility, and increases utilization. A Canadian geoscience database system should incorporate all relevant existing and future earth science data considered to be of value to the nation. The system should also be fully compatible with the Geographical Information System of the SM&RS Sector.

There is a particular urgency to develop the national geoscience database so the basic data continue to be of value to industry as well as Government. In recent years the private sector has become increasingly dependent on automated data systems and has gained extensive experience in many aspects of data acquisition, organization and computerization. Computer-aided integration and analysis of these data provide valuable basic information which can point to potentially favourable areas worthy of the intense further investment and exploration required to locate a drilling site or to open up a mine.

Creating the original database file and converting the raw data to machine-intelligible form is no easy task, nor is it cheap. The unusual degree of variety which characterizes geoscience data creates a measure of complexity somewhat unique in database systems and their management.

Provincial participation would be necessary for a truly national geoscience database and would require agreement for access to provincial data holdings. It is important that activities be coordinated with provincial government agencies to set standards for data formats, interchange, and uniformity of content and coverage. Joint committees are required to ensure that both local as well as national needs are met wherever possible, and in the most cost-effective and efficient manner. Responsibility for producing, operating, maintaining, and overall management of the database would remain under the close direction and control of GSC.

RECOMMENDATIONS

6. The creation of a modern computerized database system that incorporates all relevant existing data should be one of the highest priorities of the GSC, in collaboration with provincial surveys and industry.

7. That the GSC develop its capabilities and competence in digital and computer-based information processing and evaluation technologies to exploit adequately the information contained in the national database, and to meet the needs of industry, government, and academia.

b. Environmental Consideration

i. Environment

Our greatest natural resource is the land itself including the water we drink and the air we breathe. Geological processes continually modify and reshape the land surface. None of the changes are neutral in their effects on the land or on humans, and while many effects are benign, some are clearly menacing. In addition to natural hazards are the induced hazards, i.e. the risks and damages to mankind arising from ignorant or unthinking methods of resource utilization.

Many problems concerning the environment require factual, impartial scientific information and analysis for their resolution.

ii. Hydrogeology

Water, the major fluid component of the Earth System, is also the most global in its movement and effects. The hydrological cycle moves water from the oceans to the atmosphere to the land and back to the oceans. Hence the science of geology inevitably includes the study of water and its effect on rocks.

Environmental problems cannot be resolved by the study of rocks or of water alone. From a scientific standpoint, the study of ground water is dependent upon the study of geology. Few agencies in Canada are better equipped or better suited to deal with issues concerning the properties and characteristics of natural water, its distribution and effects on the environment than the Geological Survey of Canada. To include mapping and research of water resources and related topics under the GSC is an essential move.

Routine hydrogeological studies and some first-rate research were carried out by the Survey until the mid-1960s when these activities were transferred to the Inland Water Branch of EMR and then to DOE. The DOE has done a good job of data collecting. However, the federal presence in groundwater research has virtually evaporated and Canada relies on the excellence of a few professors in university departments to keep it abreast of developments in this increasingly important and fast-moving field.

Although groundwater research impinges upon and draws from many fields, e.g. engineering, physics, chemistry, mathematics, and microbiology, its spiritual home is in geology and geochemistry and its operations are all within a geological framework. The USA offers one of several good national examples to follow – many agencies carry out groundwater studies or monitoring programs of one kind or another, but the basic research is carried out by the USGS.

We are convinced that in our country the GSC must renew and spearhead the federal presence in groundwater research. It must draw upon the data collected by DOE and other agencies to improve the modelling of groundwater movement and to devise ever more sophisticated methods of detecting and preventing environmental contamination.

RECOMMENDATION

8. The GSC should become fully active in integrated investigation and assessment of surficial geology and hydrogeology, addressing as well the interfaces of land use, climates, global change and environmental concerns such as the quantity and quality of water in the biosphere. This should be an extension of the present active Quaternary and surficial geology function.

c. Geoscience and Public Health

i. Earth Hazards

There is another, social, need for geoscience work, in the human dimension to study and understand geological and other geoscientific relationships with the environment, including natural hazards and those induced by human activities. The recent Chicoutimi earthquake shows that no part of the country is secure from natural hazards. On the basis of new information on fundamental earth mechanics, many geologists predict that British Columbia will have a violent earthquake before the end of this century, but they have neither the necessary local geological measurements nor the understanding to predict when or where it will occur, not how disastrous its intensity may be.

In addition to the natural hazards are the induced hazards, i.e., the risks of damage to mankind arising from the utilization of resources, including the direct effects of resource extraction, and the secondary and tertiary effects induced by the refining, manufacturing, and use of the products derived from the raw materials.

The Department of Health and Welfare in Canada bears the responsibility for public health and the nation bears the cost of maintaining the service.

Industry has been a leader in proving that prevention is better than cure, and has shown that an investment in maintaining fit and healthy employees yields excellent returns. The goal is to eliminate the causes of ill health, rather than to treat the symptoms.

Any reasonable effort to determine and eliminate the sources of illness and disease can only be of benefit to the nation.

Epidemiological studies in many countries have shown distinct geographical differences in health and mortality risks. Such studies reveal variable patterns of incidence of degenerative diseases. For example, in the United States, where the data systems are most sophisticated, cancer and cardio-vascular mortalities are shown to be much lower in the Midwest and Southwest than in the West Coast, Great Lakes, and Eastern States.

There is a growing acceptance that the geographical incidence of disease is related partly to elemental concentrations in diets of the so-called carcinogenic metals (As, Be, Cd, Cr, Fe, Pb, and Ni) and these in turn can be related to chemical fallout, to soils and ground water, and hence to geology and hydrogeology.

Many other examples of the relation of health to geoscience are obvious: the urban pollution of groundwater, the choice of waste disposal sites, the indoor radon hazard (radon leaks from underlying rocks and is trapped in buildings), and the contamination of runoff and irrigation waters by fertilizers.

ii. Previous Activities

Occasionally, medical scientists in several parts of Canada have called upon university geoscientists on an ad hoc basis to supply geological and geochemical baseline data for their epidemiological studies.

Over many years, Harry V. Warren and the small groups he has gathered around him at various times at the University of British Columbia have carried out work on nutrition and health in relation to trace elements in the soil. Warren and his teams have worked with medical epidemiologists in this country, U.S.A. and U.K. Their work is known and respected much more abroad than in Canada.

Provincial government geological surveys, mines divisions, and environmental units, usually in conjunction with university scientists, have carried out hydrogeochemical studies and investigations of waste disposal sites, mine tailings, etc. again on and ad hoc basis. To the best of our knowledge, the GSC has not played an active role in health geoscience.

The Geological Survey has a strong staff of Quaternary geologists, geochemists, and mathematical geologists. It is in an ideal situation to address data gathering and interpretation activities relevant to the relationship of health to geoscience. This would be enhanced dramatically by a new initiative or grouping which would bring governmental hydrogeological activities together in the Survey.

RECOMMENDATION

9. We recommend that a GSC Health Geoscience section be set up with links to the Department of Health and Welfare. The mandate of this unit should be to gather and assemble new and existing geoscience data pertinent to the environment, hazards, disease, waste disposal, and other aspects related to health. It should also be responsible for stimulating and coordinating research in health geoscience within the GSC, within other federal and provincial agencies, and within the university community.

d. International Geology

By nature, geological processes are global processes that transcend ordinary political or physical boundaries. International networking in the sciences has accelerated enormously as modes of communication and travel have improved.

More and more, major advances in science and technology come from international teamwork and less and less from individuals. Canadian academia and government and, in a different way, industrial geoscience are all part of the international science network.

The Survey has been the major coordinator of Canadian participation in the network from its beginning, acting to coordinate and catalyze the involvement of Canadian scientists in international projects, to effect bilateral and multilateral exchanges, and to provide advice to Government on foreign aid projects. Some examples include successful involvement in the International Geological Correlation Program (IGCP), the Ocean Drilling Program (ODP) and with the Lithoprobe homologues in other countries.

Several countries, including U.S.S.R., Spain, West Germany, and China, have formal agreements for unilateral exchange with the Survey. The widely read, international geoscience magazine, Episodes, was edited and published by the International Office of GSC on behalf of the International Union of Geological Sciences.

Although part of all this is done through a small but active International Geology Office, the GSC has no Foreign Geology Division or similar corps devoted to overseas work as do the U.S.A., U.K., France, Germany, and many other countries. International coordination is not part of the GSC mandate so the Survey has found it necessary to develop and continue this important role on a largely sub rosa basis. Accomplishments have been obtained through the dedicated efforts of a few individuals whose official duties lie in other spheres, and with money that must often be diverted from other purposes.

Pressure for increased involvement in international projects continues to grow because of greater public awareness of:

1) Environmental deterioration associated with worldwide Global Change.
2) The need to take the initiative in spheres of vital interest to Canadians, for example, joint projects of the Arctic boundary countries.
3) The need for more informed decisions concerning assistance to developing countries.

The GSC has done an outstanding job of coordinating the Canadian community's efforts in international geoscience as well as playing a leading role in its own right. It has done this without international geoscience being recognized as an important part of its mandate or of its budget.

In Canadian International Development projects, GSC's only role is to provide advice to CIDA when requested. Our understanding is that CIDA does not request advice on all its geoscience projects, while other government agencies, which may require geoscience advice from time to time, seldom make use of the talent pool available within the GSC.

RECOMMENDATIONS

10. That the GSC legitimize and fully recognize its present international activities and the need for their expansion by increasing substantially the funding of the International Geology Office. This Office should also administer the funding for bilateral exchanges, international projects, and the seconding of Survey officers to its staff for various assignments. In due course, GSC should consider establishing a Foreign Geology Division.

11. The GSC should be recognized as the official advisor to all arms of Government on matters concerning international geoscience.

e. Research

Most of the past and present activities of the GSC include a research component. These have spanned the range from development-type activities related to specific geoscience problems to investigation which can be labelled as 'pure' research, in the sense that use or application of the knowledge created may not be made for a considerable period of time.

Projects have included applied research in support of GSC's major clients, the mineral and petroleum industries, e.g. downhole geophysical techniques as an aid to prospecting. They have further contributed to the recruitment and retention of a large group of competent research scientists. It is widely acknowledged that the opportunity to carry out research as part of their regular duties is a major motivator for science professionals.

It must be noted that trends in research worldwide are more and more toward group and team efforts, as the topics under investigation become ever more complex and multi-disciplinary. Approaches to these problems tend to be 'mission oriented' with carefully established national goals of expanded understanding and broad application, as seen in the highly successful continent-wide Lithoprobe initiative for deep crustal investigation.

Earth Sciences research and development in Canada is shared between the universities, the private sector, and the federal and provincial government institutions.

The University reward system and peer structure tends strongly to direct the course of its efforts toward fields of pure research. However, the same culture is often enticed by currently fashionable topics, which may leave major shortfalls in the overall national balance of scientific effort.

Industry, on the other hand, with the exception of a few very large organizations such as major oil companies, does little or no pure geoscience research. It tends to focus on applied research and on product development based on the fundamental research done at universities and other centres.

The bulk of government Earth Science research and development has been carried out by the GSC. Provincial agencies have concentrated on resource management activities, on highly focused mapping programs in support of local industries, and on selected detailed mapping.

Clearly there is a critical but complex role for the GSC to play in Earth Science research. Fundamental research is international, often long term, and potentially fickle. It is probably best left to academia, unless a connection to constructive application can clearly be shown.

However, research must be undertaken by the GSC to support the broad spread of present developments and to address the equally broad array of contemporary problems. This implies it must be mission driven, with specific goals and objectives, and that it carries accountability.

Further, it should be the GSC's responsibility to ensure that the appropriate and necessary research takes place. This implies that a combination of contracting, of financial support, of joint venture, or of other processes should be used either as an alternative to, or in combination with, or as an adjunct to, an ongoing level of in-house research conducted by the Survey itself. The Survey's best role can be stated as performing an optimization function designed to ensure the best combination of all types of geoscience investigations occur within Canada. The Survey should become as much a research manager and research entrepreneur as a stand-alone researcher.

f. The GSC Role in the Public Appreciation of Science

i. The Need

The economic importance to Canada of exploiting our natural resources, minerals and fossil fuels has not diminished, but has become overshadowed by growing alarm and concern over the rapid deterioration of the air, water and land of the Earth's crust, and the threats posed to the systems that support life. The environment is now the main scientific concern of the public at large.

The GSC should be a major governmental agency to determine solutions of environmental problems. But public resolution is hampered by a lack of balanced informed opinion. The issues become more emotional than factual. Government has an obligation to ensure that a concerned public becomes an informed public and this may not be an easy task.

Studies conducted by the Ministry of State for Science and Technology in the mid-1970s, and reaffirmed as recently as 1987, showed that the average Canadian knew little and cared less about the sciences. Two-thirds of those surveyed could not name a Canadian scientist living or dead. Similar studies show the bulk of the U.S. population also have little interest in science, and of the 20 percent who profess to be interested, most can be classified as scientifically illiterate.

These facts are alarming at a time when legislation at all levels of government increasingly involves a scientific or engineering component. Citizens are less capable of contributing properly to a participatory democracy when they lack an appreciation of science.

The public must be educated on the tradeoffs between its wants and the costs of sustainable development and the depletion of non-renewable resources, on the means to avoid overtaxation of the planet's waste-carrying capacity, and on the global effects of loss of biodiversity by the extinction of species.

Agencies and individuals involved with science and engineering need to recognize the social implications of their work and should endeavour to share their knowledge with their fellow citizens.

ii. Previous Activities

The Geological Survey of Canada, historically the leader of Canadian geoscience, probably has a better record than most federal scientific and technological agencies in communications with the general public, and has a major role to play in enhancing the public's awareness of science.

For many years, the Victoria Memorial Museum was a part of the GSC so that many survey scientists became involved in public communication. Entrusting GSC with the maintenance and display of the proposed Pinch Mineral Collection could help revive popular appreciation for government efforts in the science sector.

In recent years the Survey has become well known for its rock-and-mineral sets designed for school children, for the sporadic publication of semi-popular guide books to mineral localities and geological scenery, and also for summaries of the geology of Canada.

However, it is probably fair to state that much of the GSC's recent concern with public awareness has been directed toward advertising its own activities, and its products have been targeted towards a select, informed audience. Only a very small percentage of its scientific staff appear to be active in the communication process.

The GSC must actively help to remedy the low level of interest in science, particularly among young people. If allowed to continue, the present situation will lead to drastic shortages of competent professionals and researchers and hence an inability to meet national challenges in the future.

RECOMMENDATIONS

12. Individual scientists of the Survey must be encouraged to view their work in the social context and to inform the public of its significance.

13. The Survey should recognize lucid communication of science and other contributions to the public appreciation of science as valid elements in career advancement of scientists.

5. STRUCTURE AND ORGANIZATION

a. Decentralization

The Survey operates with five satellite offices and several divisions. However, its overwhelming strength is in the Head Office at Ottawa. The Vancouver and Calgary offices have been highly successful in their interaction with specific clients – the mining and petroleum industries. In spite of this, a widespread perception persists that the Survey is Ottawa-based and rather remote and inaccessible.

Consistent with conclusions and recommendations elsewhere in this Report, it is believed that as the Survey becomes more active in the entire range of Earth Sciences, the need will arise for the Survey to decentralize and become interactive with the community as a whole. A few additional carefully selected regional offices should be established with appropriate staffing.

Regional offices must be strongly supported in terms of database access, publications, etc. They should be the vehicle for joint ventures of various types with Provincial Government and regional university systems. They should be accessible to the community at large and should be proactive in the Survey's dealings with society.

Specific expertise should be deployed to appropriate centres; e.g. there should be a strong geophysical presence in the ISPG office at Calgary to match the major level of geophysical effort in the private sector in that area; likewise seismology and natural hazards should perhaps be strengthened in Vancouver; observations stations associated with the Global Change program could be coordinated from Winnipeg.

b. Inter-Agency Relationship

A concern with natural resources was part of the original motivation for a national Geological Survey. Subsequently, under the 1867 BNA Act, control of natural resources was declared a provincial responsibility. It is ironic that much of the Survey's success and its major clients are in the resource sector, a situation which from time to time, has led to confusion between the role of the Survey and that of other agencies involved.

i. Provincial Surveys

Most of the provinces, in order to assume responsibility for their mineral resources, have set up their own Provincial Surveys and have, through the years, provided them with varying resources. Generally, the mission of a Provincial Survey is to elaborate and execute plans and programs designed to stimulate and promote mineral exploration, and to improve its efficiency, within the Province.

The interest of the Provincial Surveys in having a federal presence in their territorial jurisdiction varies greatly from one to the other, often in proportion to their self-sufficiency in terms of geoscientific studies.

Clearly, the GSC's role is not one of regional nor local resource monitoring or management. These are provincial affairs, but it is the Survey's duty to provide support and assistance where mutually agreed. The GSC has had, and will likely continue to have, a supporting role to play in the provincial mineral sector.

The Survey also has a national responsibility to address resources as a whole, bringing a knowledgeable perspective to the understanding of the origin and distribution of resources as a means to improve exploration. Its role must include overall monitoring and integration, the provision of national databases, and judicious involvement with research programs designed to enhance national levels of understanding of resource industry geoscience.

ii. The Territorial Surveys

Currently the BNA Act gives the Federal Government jurisdiction over the mineral resources of the Yukon and the Northwest Territories, but there well could be some future participation by the two Territorial Governments. Both Territories have small geological surveys similar to those of some provinces and with similar mandate. Because of the historic jurisdictional differences between the territories and the provinces, the GSC has always assumed de facto full responsibility for the collection of geoscientific data over these vast, rich and relatively unknown territories.

iii. The Universities and Institutes

Geoscientists from the Canadian academic community, through scientific research, have contributed considerably, through the years, to the advancement of the geoscientific knowledge of the Canadian landmass and offshore. Their research is funded mostly from four different sources: federal and provincial granting agencies; universities' internal funding; GSC contracts to the universities and summer employment to professors and students; and from the private sector (mostly petroleum and mining companies). The geoscientific work carried out by this community varies from fundamental to applied research and the methods range from observation and experiment to synthesis and compilation.

iv. The Petroleum and Mineral Industry

The petroleum and mineral industries have acquired and contributed massive amounts of geoscientific information and knowledge of Canada's landmass and offshore. A portion of this important information makes its way to the public domain through publication, donation, and from the assessment files maintained by the governments. Unfortunately, a substantial volume of these precious data remains in files and is never used effectively. All agencies concerned would benefit from a central national geoscience database developed by the GSC in cooperation with the appropriate provincial and industrial entities.

RECOMMENDATIONS

14. The GSC should focus its activities on topics where overlap with the specific mandates of the Provincial Surveys is minimal.

15. The excellent degree of cooperation developed between the Federal and Provincial Governments, through the Mineral Development Agreements (MDAs) for geoscientific surveys, should be maintained.

16. The GSC should play a role, monitoring and coordinating the main geoscience activities carried out on the Canadian landmass and offshore by the GSC, the Provincial and Territorial surveys, the universities and institutes, the mining and petroleum companies and the consultants and service firms.

6. ROLE IN GOVERNMENT

The Committee recommends that the Geological Survey of Canada should be the national general science and technology institution dealing with all aspects of earth science. A strong Geological Survey is essential for national well-being; and this body should address all aspects of geoscience, including environmental, hydrogeological, and health considerations, some of which appear to lie outside the present mandate of its parent, the Department of Energy, Mines and Resources.

This raises some question as to the appropriateness of the status of the GSC as a unit within EMR. The Committee discussed possible alternatives, including the concept of creating a separate institution along the lines of the National Research Council.

Such a move would perhaps improve the GSC effectiveness across ministerial boundaries, particularly where Earth systems science becomes more environmental, as is the case with hydrogeology, glaciation studies, climate response, earthquakes and other natural hazards.

On the other hand, a dynamic Department, such as EMR, with high national priorities might achieve the necessary more appropriate allocation of resources to the Survey.

No recommendation is made here, beyond urging that appropriate levels of government consider all the implications of the issue, while recognizing the fundamental value of a broad all-embracing Geological Survey.

The Chairman of the Committee thanks the Co-Chairman and all members for their thoughtful and penetrating views on the role of geoscience as an agency for progress in Canada and the World, and in particular, the drafting of the final version by Hugh Morris, and the careful proofing and editing by Ward Neale.

It has been an exhilarating exercise to work with the talented and dedicated members of the Committee.