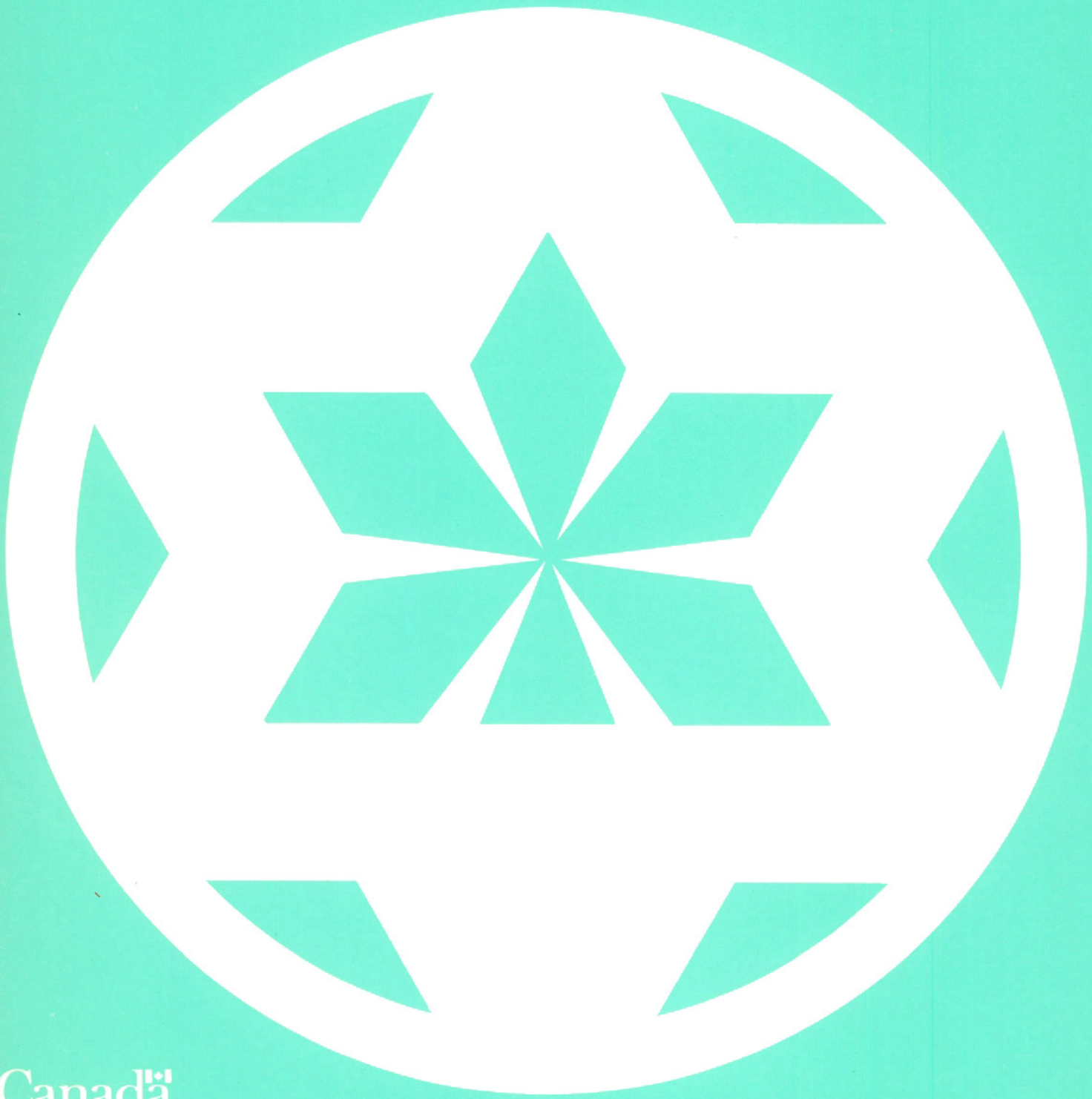
CANADIAN GEOSCIENCE COUNCIL

The Geosciences in Canada, 1985

Part 2: Report of the Canadian Geoscience Council Advisory Committee on Mineral Deposits Research at the Geological Survey of Canada

Published for the Council
by the Geological Survey of Canada
as Paper 85-6, Part 2

Advisory Committee
A.J. Naldrett (Chairman), R.J. Cathro, E.L. Hoffman,
R.Y. Lamarche, R.H. Wallis



Canada

GEOLOGICAL SURVEY OF CANADA
PAPER 85-6, Part 2

THE GEOSCIENCES IN CANADA, 1985

Part 2: REPORT OF THE CANADIAN GEOSCIENCE COUNCIL ADVISORY COMMITTEE ON MINERAL DEPOSITS RESEARCH AT THE GEOLOGICAL SURVEY OF CANADA

Prepared by the
CANADIAN GEOSCIENCE COUNCIL

Advisory Committee
A.J. NALDRETT (Chairman)
R.J. CATHRO
E.L. HOFFMAN
R.Y. LAMARCHE
R.H. WALLIS

1986

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
601 Booth Street
Ottawa, Canada K1A 0E8

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

Cat. No. M44-85/6-2E Canada: $4.00
ISBN 0-660-12142-5 Other countries: $4.80

Price subject to change without notice

Cette publication est aussi disponible en français

CONTENTS

Preface

For some years the Geological Survey of Canada has followed a policy of having external peer reviews of aspects of its scientific operations. This has been coupled with mandatory ongoing operational audits and reviews conducted by internal departmental (Energy Mines and Resources) or interdepartmental teams. These processes have provided a series of checks and balances against which the scientific and administrative procedures in use at the Geological Survey could be judged in terms of the efficiency and effectiveness of the use by the Branch of its allotted financial and manpower resources, and of the relevance and timeless of its scientific output.

The principal vehicle of external peer review has been the Canadian Geoscience Council. From time to time, Advisory or Review Committees nominated by the Council and composed of representatives from the Geological Survey's main 'client' sectors (industry, academia, other federal and provincial government agencies) have evaluated and reported on aspects of the Branch's activities in particular fields of research.

This report is the result of one such Advisory Committe review. The topic of mineral deposits research has been receiving increasing attention in Canada (as elsewhere) over the past few years, and since the Geological Survey devotes a significant part of its resources to mineral deposits research and related matters, it was considered timely to critically review this activity in the Geological Survey of Canada where it comprises a major component of the total research effort in the field by the Canadian geoscientific community.

This document contains the Report of the Canadian Geoscience Advisory Committee on Mineral Deposits Research at the Geological Survey (a committee chaired Professor A.J. Naldret of the University of Toronto) and a Commentary on that report prepared by the Geological Survey. The Commentary is not intended as a detailed review of the Advisory Committee report. Rather, its purpose is to discuss some of the major conclusions that are contained in the Committee report and their implications for the Branch. The Commentary deals with those areas in which the Branch is in agreement with the Committee's conclusions, as well as those areas in which there is disagreement; and it discusses the basis of such disagreement.

When this Advisory Committee was established the Terms of Reference provided for release of the report to the public, the method to be determined by the GSC and CGC. It seemed appropriate for publication to be through the GSC Paper series in which the CGC Annual Reports are published and in which previous special studies have been published. The approved manuscript for this report was forwarded in August 1985 to the appropriate GSC division for publication production in English and French editions.

The Geological Survey wishes to record here its appreciation to the Canadian Geoscience Council, in general, and to the Naldrett Committee and its members in particular, for the conscientious, and prompt manner in which the review was conducted. The study will be of major benefit to the Geological Survey; some of the recommendations made by the Committee are already being implemented, and others are currently being examined to determine the mechanisms and feasibility of implementation.

R.A. Price
Director General
Geological Survey of Canada

CGC Advisory Committee Study of GSC Mineral Deposits Research

TERMS OF REFERENCE

1. To determine and document the current level and types of mineral deposits research in the Geological Survey of Canada.

2. To assess its relevance and adequacy to users in industry, university and government sectors, and for Branch and Departmental national responsibilities mandates.

3. To assess the timeliness, relevance, quality and quantity of publications reporting on the results of mineral deposits research at the Geological Survey.

4. To assess the range, adequacy and quality of research equipment, support staff and analytical services available to support mineral deposits research.

5. To examine the methods and procedures used in originating, implementing, assigning priorities and managing mineral deposits research projects.

6. To identify new initiatives and opportunities for Geological Survey of Canada research.

7. To make written recommendations, as appropriate, to the Director General, Geological Survey of Canada concerning ways in which the quality and effectiveness of mineral deposits research and reporting of results might be improved. The Canadian Geoscience Council Committee shall report its findings and appropriate recommentations in writing to the Director General, Geological Survey of Canada. The report of the Committee shall be made public, but the mechanism and format of publication shall be determined by mutual agreement of the Director General, Geological Survey of Canada and the Chairman of the Canadian Geoscience Council Committee.

8. Unless otherwise agreed to by the Director General, Geological Survey of Canada and the Chairman, Canadian Geoscience Council Committee, the Committee's report shall be submitted to Geological Survey of Canada within one year of the formal commencement of the study.

R.A. Price
Director General
Geological Survey of Canada

February, 1985

PART I

Report of the Canadian Geoscience Council Advisory Committee on Mineral Deposit Research at the Geological Survey of Canada

1.0 INTRODUCTION

The Canadian Geoscience Council Advisory Committee to the Geological Survey of Canada on Mineral Deposits Research was struck as a result of a request from Dr. R.A. Price, Director General of the Geological Survey to the Council in November 1983. The Council requested suggestions for names of possible members of the committee from its constituent associations and also from the Geological Survey, from which it selected a short list of names. These were given to the Director General who selected five individuals to constitute the committee, requesting one of them to act as chairman and giving them the Terms of Reference attached to this report as Appendix A. The committee commenced its work early in March 1984. An outline of its activities is attached as Appendix B.

Starting points for the Committee in their work were Geological Survey of Canada Paper 82-6, Part 1 (a report to the Canadian Geoscience Council by a committee chaired by A. Coope) and a brief prepared under the direction of D.C. Findlay Director, Economic Geology and Mineralogy Division (EGM), (Appendix C). Both documents were extremely helpful. The Committee is aware that many of their conclusions and recommendations echo statements made in these documents. The Committee is, however, conscious that this input was received at an early stage,

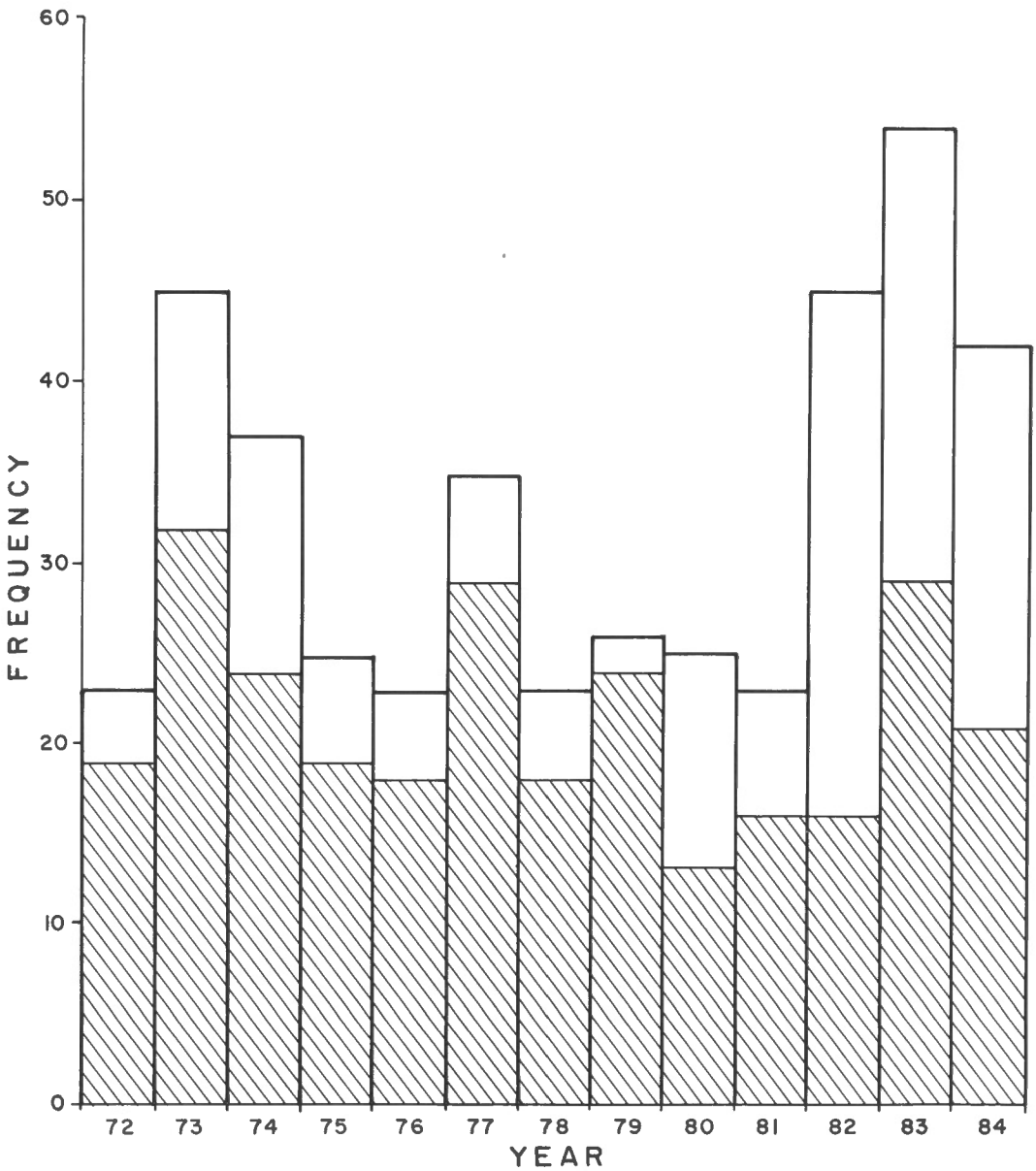


Figure 1.1. Distribution of all Canadian projects undertaken by Derry, Michener, Booth and Wahl by year, distinguishing those that made some use of GSC output (shaded area). (Source: Derry, Michener, Booth and Wahl).

before input from its own questionnaire (Appendix D) and its series of interviews with personnel from the Department of Energy, Mines and Resources and invited discussants. Thus any similarities reflect the Committee's opinion after its own independent evaluation of the situation.

One of the first tasks faced by the Committee was that of defining what they meant by 'mineral deposits research' and this is presented in Section 2.0 of this report. The definition led directly to the Committee's perception of its mandate – those activities within the Geological Survey of Canada that it felt competent to review and those that it did not (Section 3.0). Much of the body of the report (Section 4.0) is concerned with the Committee's assessment of the present status of mineral deposits research within the Geological Survey including the structure and inter-relationships of the different units conducting research, the research objectives, and an analysis of the research undertaken by individual units.

In the course of its work, the Committee saw many fine things that have been, and are being done at the Geological Survey in mineral deposits research. Some of these are outlined in this report. Many of those responding to the questionnaire made it very clear how important the role of the Branch has been to their own work. This was brought home particularly strongly to the committee in the brief presented by Dr. David Wahl. Figure 1.1, which is taken from his brief, illustrates the proportion of the total Canadian projects undertaken by Derry, Michener, Booth and Wahl over the past 12 years, that depended to some extent on a Geological Survey of Canada contribution. Although not all of this contribution involved mineral deposits research, Dr. Wahl made it clear that these individuals had had a substantial input to this contribution.

The Committee also saw things that, in its view, could be improved. Paramount amongst these was the perception that senior management has appeared to give a low priority to research in the past. This is particularly noticeable in an apparent lack of interest in what mineral deposits research can achieve. Traditionally, there appears to have been little planning of research initiatives and consequently, no strong focus on overall objectives to much of the work. The Committee could detect little in the way of attempts to achieve an integration of research effort – in consequence, the strong have forged ahead on their own following a variety of paths, but the less strong have been left to survive with little direction. The Committee notes that the Geological Survey is aware of this situation and is attempting to reach a solution.

The Committee suggests the establishment of an internal planning group which will accept advice both internally and externally, and set clearly defined 'thrusts' involving teams of researchers. The mechanisms for doing this and suggestions as to some of the thrusts form the subject matter of the final section (Section 5) of this report.

This introduction would not be complete without an acknowledgment of the enormous amount of help provided by the Geological Survey to the Committee. This included logistical support in terms of facilities for meetings and secretarial services in all aspects that were not confidential to the Committee alone. It also includes the time taken by the Director General, Dr. R.A. Price and Chief Geologist, Dr. J.G. Fyles, in providing frank answers to probing questions and by all individual scientists and administrators who met with the Committee, many of whom had put considerable time and thought into preparing written briefs. Most of all we have to acknowledge Dr. D.C. Findlay who was continually helpful and who, despite the critical tone that coloured our discussions from time to time, remained friendly, open, and frank. If this report is helpful to the community and the Geological Survey, it is the Survey itself which deserves the major credit. Its failings can only be attributed to the Committee, since we had only to ask for anything that we required or wished to know.

1.1 CONCLUSIONS

C4.1.1	The GSC budget for mineral deposit research in the 1983-84 fiscal year is about 2.5 million, or about 5 per cent of the total GSC budget.
C4.1.2	Research activities crosscut the EMR organization chart and approximately 40 per cent of the budget for research related to mineral deposits is performed by scientists outside of the Economic Geology and Mineralogy Division, and in some cases outside the GSC (other agencies in EMR).
C4.2.1	That service functions of many individuals bear relatively little relationship to their research functions.
*C4.2.2	That research topics, in large part, are generated from the bottom up.
*C4.3.1.1	Although performance of the service function depends on research, there is a perception amongst many scientists (but disputed by management) that service always takes precedence over research.
*C4.3.1.2	Personality and initiative are as important as talent in influencing productivity in mineral deposits research within the GSC.
C4.3.2.1.1	The EGM mineralogy laboratory is well equipped but is perhaps being under-utilized.
C4.3.2.2.1	The EGM chemical laboratory is outdated and is overstaffed for the amount and type of work being done.
C4.3.2.3.1	The Resource Geophysics and Geochemistry (RGG) chemical laboratory is progressive in nature and generally is run efficiently, partly because of its close involvement with research into and the development of techniques.
C4.3.2.4.1	The mathematical applications group is highly regarded, however it appears to be under-utilized by the rest of the GSC.
C4.3.2.5.1	The work of the data interpretation unit represents an exciting development of much promise to industry.
C4.3.2.13.1	The theoretical modelling group are working on projects which, when initiated 5 to 7 years ago, were relevant, but which have become less relevant with time.
*C4.3.2.14.1	The commodity approach to research has not been overly successful within EGM.
*C4.3.2.16.1	In a research environment where research topics are generated by the individual scientists, superior scientists function well but lesser scientists are not able to work efficiently. Some scientists engaged in mineral deposits research are in the second category due to the shortness of their apprenticeships and the absence of an effective method of ensuring their response to periodic assessments of their progress.

* Considered to be important conclusions and recommendations.
** Considered to be most important conclusions and recommendations.

**C5.1.1 The lack of a system for defining the objectives of mineral deposits research and for evaluating research effectiveness is the single most serious problem with respect to mineral deposits research within the GSC.

1.2 RECOMMENDATIONS

R1 That another, differently constituted committee be formed to advise on the activities of RGG division.

R4.3.2.1.1 The acquisition of large capital equipment items for the mineralogy laboratory, such as the EMR-NRC proposal for a Canadian micro-PIXE laboratory should be undertaken jointly with CANMET and/or other government (both federal and provincial) departments and universities.

R4.3.2.1.2 Polished section preparation be centralized in CANMET and much routine thin section preparation be contracted out, as is the case at present with polished thin section preparation.

R4.3.2.2.1 The EGM chemical laboratory should be modernized with the acquisition of state of the art instrumentation and appropriate support personnel.

R4.3.2.2.2 Routine sample analysis should be contracted out to commercial analytical laboratories, with contracts being managed and monitored by staff of the EGM chemical laboratory.

R4.3.2.2.3 That a realistic costing of internal analytical work be instituted, with costs to be paid out of 'paper funds' allocated to the budgets of individual projects.

R4.3.2.3.1 After allowing a two year period for the EGM chemical laboratory to adjust to its new situation, a study should be undertaken to determine whether the RGG laboratory should be combined with the EGM chemical laboratory.

R4.3.2.4.1 The mathematical group should try to narrow the gap between its state of the art work and the work of colleagues in the GSC and integrate more closely into the various projects within EGM.

R4.3.2.5.1 Amongst its programes the data interpretation unit should concern itself with the evaluation of data generated by RGG using or adapting the sophisticated regional interpretation techniques that are employed in other countries.

*R4.3.2.6.1 That all mineral deposits data should be integrated into one computerized file and the non-confidential information in it should be made telephone-accessible by the general public.

R4.3.2.10.1 That because of its mineral deposits research opportunities, the Pacific offshore study warrants a sustained, collaborative research thrust.

R4.3.2.12.1 That, in view of the declining importance of uranium exploration and the desperate need for additional personnel to work on other deposit types, the uranium group be reduced from three to two and that the remaining two be strongly encouraged to produce a compilation and synthesis of the findings of the whole group over the past 12 years in a hard cover format within five years.

R4.3.2.13.1 That the theoretical modelling group should concentrate more of its efforts on ore deposits of current interest (e.g. seafloor, Archean gold) and that its members should become attached to teams working on these deposits at an early stage, so that they can provide input into the collection of data.

*R4.3.2.14.1 That scientists who still function with a "commodity" approach to their research should be reassigned to other projects. Those who have yet to produce comprehensive reviews of their commodity(ies) should be given a period of two to three years in which to do this before taking up their new assignments.

*R4.3.2.16.1 That a mechanism be established whereby those scientists who are given a poor assessment on the basis of their research activities be removed from the research stream and identified as contributing to other areas.

**R5.1.2.1.1 That management establish an internal advisory group which will set research policy and objectives.

**R5.1.2.2.1 That a National Advisory Committee on Mineral Deposits Research be established, composed of 8 to 10 senior geoscientists representing industry, provincial and territorial governments and universities, to advise the Minister of State (Mines) through the Assistant Deputy Minister, Earth Sciences Sector to review plans for research programmes, monitor performance, and co-ordinate views on the subject from outside the GSC on an annual basis.

**R5.2.2.1.1 That GSC management go on record as recognizing that performance in the research function is equally important to that in the service function for the advancement of an individual's career, and to achieving the goals of the GSC. Thus, on average 50 per cent of an individual's time should be devoted to research.

**R5.2.2.1.2 That management institute a planned approach to mineral deposits research, following plans set by an internal advisory group, and that individual scientists be required to work within the outline of this plan, achieving and publishing results within a pre-set time frame.

**R5.3.2.1 That mineral deposits geologists be strongly encouraged to work in teams on projects of finite duration oriented towards the intensive study of a mineral camp containing deposits of a specific type.

*R5.3.2.2 That mineral deposits geologists with relevant expertise be attached to GSC projects that are aimed at solving major tectonic-sedimentary-igneous problems of specific structural belts in Canada.

*R5.3.2.3 That mineral deposits geologists be located at certain carefully selected "key" deposits during the development and early stages of mining to contribute to the documentation of the deposits.

R5.3.2.4 That the collaboration between RGG exploration geochemists and EGM mathematical geologists should be encouraged to continue.

R5.4.1.1 That in planning and executing collaborative projects, every effort be made to respect local sensitivities, as for example provincial agencies and university groups.

R5.4.2.1 That EMR Research Agreements be increased in size and number, and that they be awarded to promote projects closely related to internal GSC research and in which GSC personnel could be active as opposed to passive participants.

R5.4.3.1 That space and funds be allocated to promote bilateral exchanges for periods of 3 to 12 months between the GSC on one hand and universities or industry on the other.

2.0 A DEFINITION OF MINERAL DEPOSITS RESEARCH

The Advisory Committee understands 'Research' to be the pursuit of new knowledge through the accumulation and interpretation of new data and the reinterpretation of existing data and ideas.

Mineral Deposits Research can be classified naturally into that orientated towards

(a) studies of the surficial environment
(b) studies of the bedrock environment
(c) studies of the deposit
(d) obtaining data to assist in interpreting observations made in (a) to (c).

Data accumulated under (c) may be used in beneficiating ore deposits; that (data) accumulated under (a), (b) and (c) for developing new empirical techniques in exploration; and, that accumulated under (b), (c) and (d) for understanding the genesis and thus assisting in the prediction of new deposits.

Sangster (see MDD Committee on Research in Mineral Deposits in, The Gangue, Geological Association of Canada, No. 8, March 1980 sic) has divided research into fundamental research (Type 1); that concentrating on the documentation of deposits using standard techniques coupled with interpretation according to existing models (Type 2); and that involving compilation on a regional scale (Type 3).

Thus, the different types of mineral deposits research can be defined according to the matrices illustrated in Figure 2.1a (GSC contributions) and Figure 2.1b (other contributions).

	Type of Research		
	I	II	III
	(Fundamental)	(Document)	(Compilation)
(a)		RGG	RGG
	ts	TS	TS
(b)	epb	epb	epb
	rgg	rgg	
	cord	egm	egm
	ispg		
	PC	PC	PC
(c)	egm	EGM	EGM
(d)	mag	mag	

EPB = Earth Physics Branch
RGG = Resource Geophysics and Geochemistry Division, GSC
TS = Terrain Sciences Division, GSC
PC = Precambrian Geology Division, GSC
EGM = Economic Geology and Mineralogy Division, GSC
MAG = Mathematical Applications in Geology Section, EGM, GSC
CORD = Cordilleran Geology Division, GSC (Vancouver)
ISPG = Institute of Sedimentary and Petroleum Geology, GSC (Calgary)

a = Surficial environment
b = Bedrock environment
c = Ore deposits
d = Ancillary studies needed to assist in interpretation

N.B. Upper and lower case letters indicate major and minor involvement respectively.

Figure 2.1a. Responsibilities of units of EMR within the Mineral Deposits Research matrix.

	Type of Research		
	I	II	III
	(Fundamental)	(Document)	(Compilation)
(a)		IND PROV	PROV
(b)		IND UNIV PROV	PROV
(c)	UNIV	IND UNIV	PROV
(d)	UNIV		

IND = Industry
UNIV = Universities
PROV = Provincial Surveys

a = Surficial environment
b = Bedrock environment
c = Ore deposits
d = Ancillary studies needed to assist in interpretation

Figure 2.1b. Responsibilities of other organizations within the Mineral Deposits Research matrix

3.0 THE ADVISORY COMMITTEE'S PERCEPTION OF ITS MANDATE

The mandate of the Advisory Committee was given to it by the Director General, Geological Survey, and is attached as Appendix A.

Once the committee started its work, interviewed scientists of the Economic Geology and Mineralogy (EGM) and other divisions, and heard from directors and representatives of other divisions, it became clear that its mandate should be restricted to activities falling within boxes b-II, b-III, c-I, c-II, c-III and, to a lesser extent d-I, and d-II of the mineral deposits research matrix (Fig. 2.2a) – in other words EGM and those activities of other divisions which relate most closely to the work of EGM. Although not exclusively concerned with mineral deposits research, the mineralogical and chemical laboratories are within EGM, and the committee felt that it had the expertise and knowledge to comment on these. It did not feel it had the knowledge to comment on the majority of the activities within the Resource Geophysics and Geochemistry (RGG) division, and suggests that this division should be examined in the near future by another, differently constituted committee.

RECOMMENDATION R1. That another, differently constituted committee be formed to advise on the activities of RGG division.

4.0 PRESENT STATUS OF MINERAL DEPOSITS RESEARCH

4.1 Structure and inter-relationships of the organizations conducting mineral deposits research

The GSC is one of four branches within the Earth Sciences Sector of the Department of Energy, Mines and Resources. The position of the GSC within the departmental organization is shown on Figure 4.1 on the following page.

The legislative mandate of the GSC is:

> "to ensure the availability of comprehensive knowledge, technology and expertise pertaining to the geology of the Canadian landmass and offshore areas, including mineral and energy resources, and conditions affecting land and seabed use, as required for effective exploitation of mineral and energy resources, effective use of land, estimation of the resource base of Canada, and formulation of policies".

Mineral deposits research is currently concentrated within EGM, which has been assigned the responsibility for applying the Survey's mandate to mineral deposits. The objective of the EGM has been defined as:

> "ensuring the availability of comprehensive geological knowledge, technology and expertise concerning metallic and other mineral deposits, of determining the geological distribution, origin and potential abundance of Canada's mineral resources to facilitate exploration, land-use planning and policy formulation, and providing composition analyses of rock, minerals, ores and other geological material".

The position of EGM within the GSC and the organizational structure of EGM are shown on Figures 4.2 and 4.3.

In addition to the 26 scientists and 14 support staff in EGM [1] who are currently engaged in mineral deposits research, the Advisory Committee identified approximately a dozen additional scientists within the Earth Sciences Sector who are also engaged in this field of research. Several of these are devoting a substantial portion of their work towards mineral deposits research and their contribution to the overall output, both in terms of quantity and quality, comprises an important portion of the total as is shown schematically in Figure 4.4. These scientists are located in the RGG, Terrain Sciences, Precambrian and Cordilleran Divisions of the GSC, and the Pacific Marine Geophysics Division of the Earth Physics Branch [2]. The combined budget of those engaged in mineral deposits research in the 1983-84 fiscal year is probably about $3 million. The GSC component ($2.5 m) of the research budget for mineral deposits research is shown in relation to the budget of the Earth Sciences Sector in Figure 4.5.

The Committee found that the present organizational structure of the GSC is not a clear guide to the location of scientists engaged in Mineral Deposits Research; research interests to a large extent cross-cut structural lines in the current organization. As a result, the Advisory Committee found it useful to prepare its own classification in which individuals are grouped according to the theme which appeared to guide their research most closely. This is described in the next chapter.

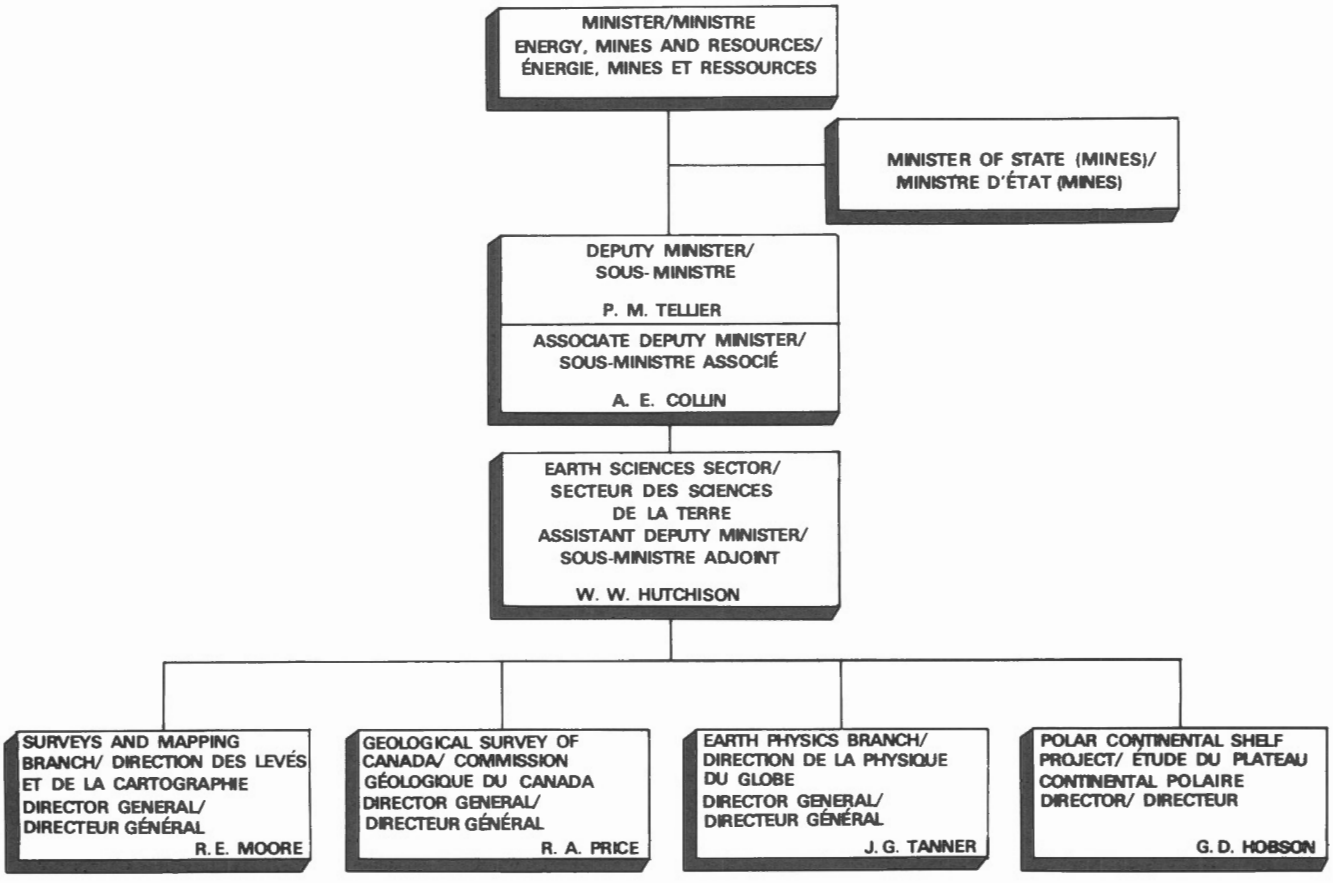


Figure 4.1. Organization chart 1983-1984.

[1] This excludes staff of Mineralogy and Chemistry Subdivision.

[2] This does not include scientists in the Mineral Processing Laboratory, Canada Centre for Mineral and Energy Technology (CANMET), Research and Technology Sector, EMR.

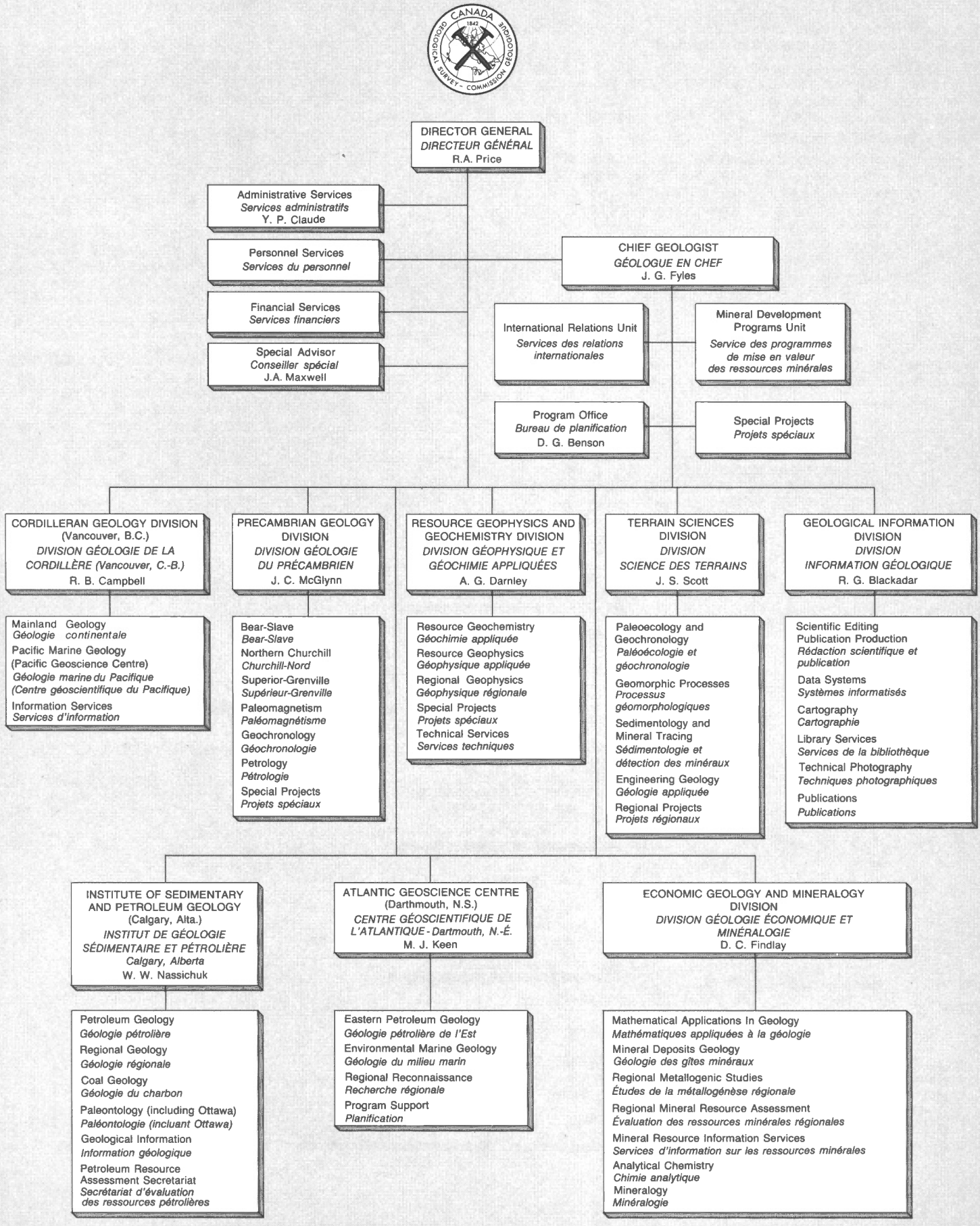


Figure 4.2. Organizational chart of the Geological Survey of Canada.

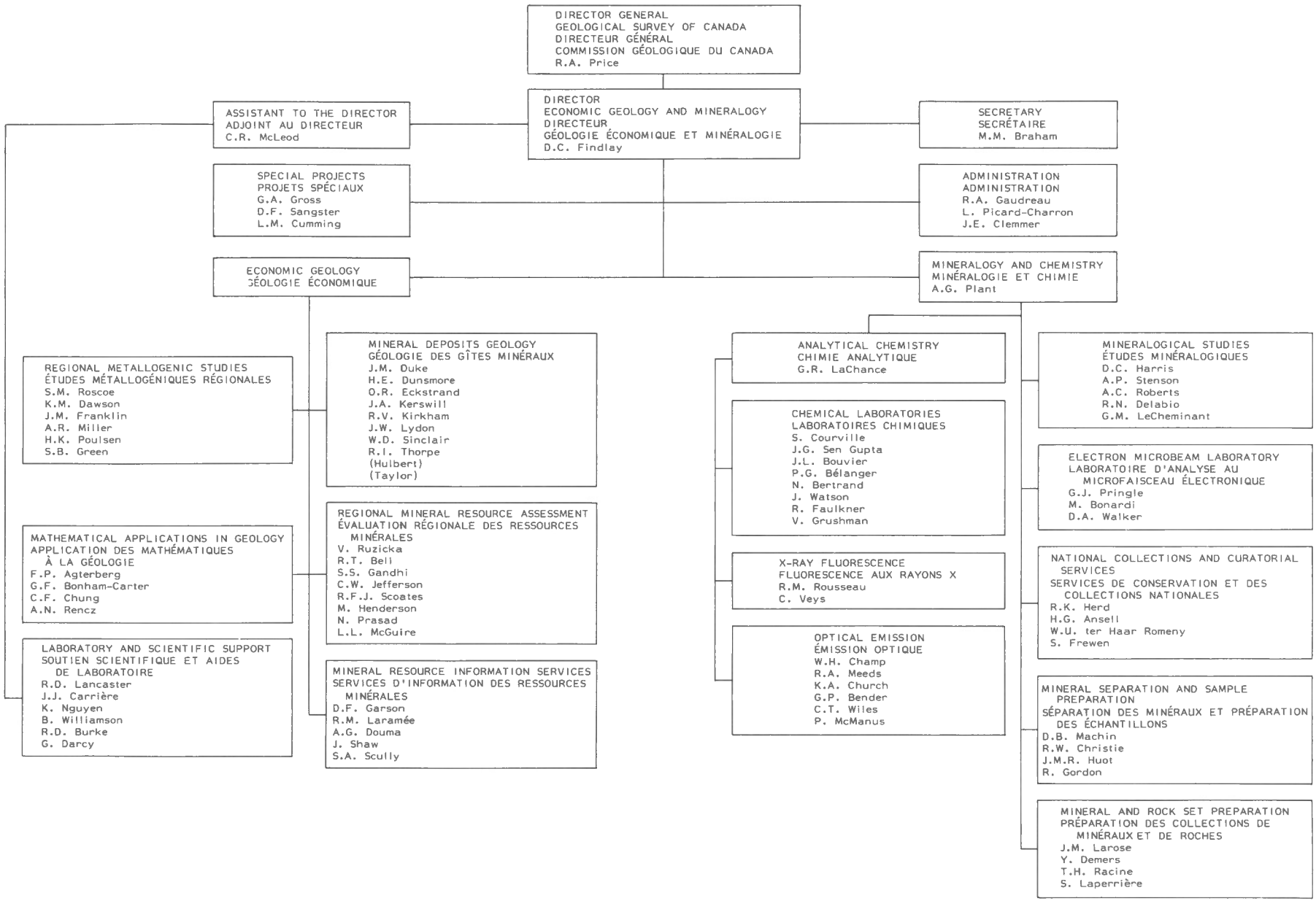


Figure 4.3. Organization chart of the Economic Geology and Mineralogy Division.

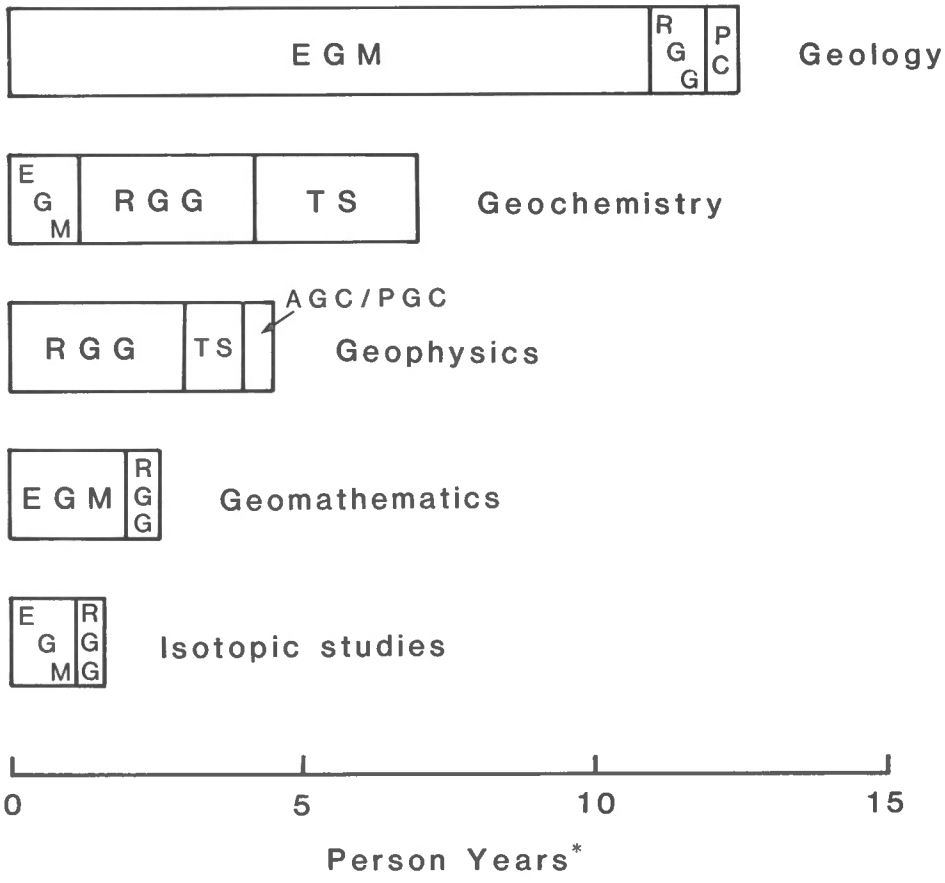


Figure 4.4

Mineral deposits research; person-year distribution by discipline area and Division organization within the Geological Survey of Canada. Note: 50% of individual scientist's time has been considered as devoted to research.

*excludes scientific and technical support and time devoted by research scientists to other responsibilities

As shown in Figure 4.2, the GSC is primarily structured on the basis of geotectonic regions; for example the Cordillera, Precambrian Region (Canadian Shield), Western Canadian and Arctic Sedimentary Basins (Institute of Sedimentary and Petroleum Geology) and the Atlantic and Pacific Continental Shelves (Atlantic Geoscience Centre and Pacific Geoscience Centre[1]). The landmass portion of the Atlantic Provinces (Appalachia) is administered from the Ottawa headquarters. In addition, however, there is also the Terrain Sciences Division, which studies unconsolidated material, geomorphic processes and natural terrain hazards, and the Resource Geophysics and Geochemistry Division (RGG), which conducts regional geochemical and airborne geophysical surveys and develops and tests geophysical and geochemical methods relating to metallic mineral exploration and economic, regional, engineering and environmental geology.

Mineral deposits research is not currently arranged in a line fashion, as mentioned earlier. This is apparently due to the historic development of the present GSC structure and the relatively low priority assigned to these studies within the GSC until very recently. It is probably not surprising, therefore, that the Advisory Committee was told of numerous instances where communication between the various working groups and individual scientists involved in mineral deposits research was weak or absent.

CONCLUSION C4.1.1 The GSC budget for mineral deposit research in the 1983-84 fiscal year is about 2.5 million, or about 5% of the total GSC budget.

CONCLUSION C4.1.2 Research activities crosscut the EMR organization chart and approximately 40% of the budget for research related to mineral deposits is performed by scientists outside of the Economic Geology and Mineralogy Division, and in some cases outside the GSC (other agencies in EMR).

4.2 Research objectives and relation to service function of the staff

Questionnaire responses indicated that considerable confusion existed in the geoscience community about research goals and objectives in the GSC. Therefore, the Committee devoted a large share of its review to this subject. In particular, it examined the questions of how research policy is developed, how alternative research choices are decided, how research goals are established and how performance in achieving these goals is measured.

While the objectives of the service functions of staff engaged in Mineral Deposits Research seemed clearly defined to the Committee, the objectives of their research functions were most unclear. One scientist who was interviewed described looking for overall research objectives as like "floundering in a swamp without map or compass".

In general the Committee recognized that the service functions bear relatively little relation to research in the case of a large number of the staff. This is not necessarily a criticism – sometimes service function and research can be well co-ordinated – sometimes an attempt to do this will

[1] Note that PGC, part of the Institute of Ocean Sciences (Department of Fisheries and Oceans) comprises the Pacific Marine Geology Subdivision of the Geological Survey, and the Pacific Marine Geophysics Division, Earth Physics Branch.

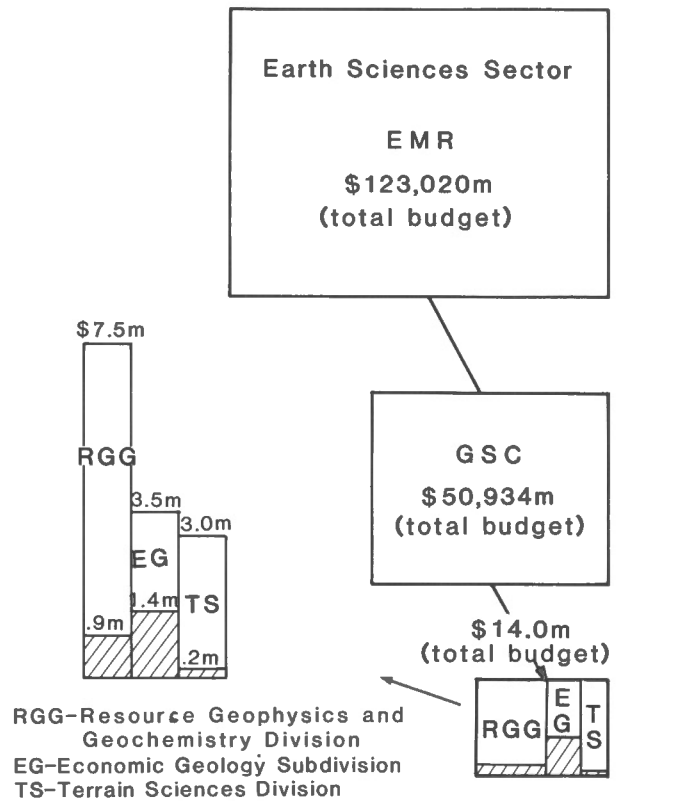


Figure 4.5. The budget in support of mineral deposits research in relation to the total budget of Earth Science Sector.

have an adverse effect on the research. It does mean, however, that the defined and co-ordinated objectives of the service function do not carry through into the research.

Research topics, for the most part, appeared to the committee to have been generated from the bottom up, with individuals proposing a topic to their section or division chief for approval. This has resulted in relatively few multifaceted, strongly co-ordinated projects being undertaken.

CONCLUSION C4.2.1 That service functions of many individuals bear relatively little relationship to their research function.

CONCLUSION C4.2.2 That research topics, in large part, are generated from the bottom up.

4.3 Analysis of mineral deposits research undertaken at the GSC

4.3.1 General remarks

One of the principal guidelines that constrain the output of individual research scientists is the dual responsibility of Service and Research that has been assigned to the GSC. Like all government line departments, one of the prime functions of the GSC is to provide advice to other federal government agencies and deliver services to its 'clients', which include industry, provincial governments, the scientific community and the general public. Among the other federal agencies that rely on the GSC for advice are the Mineral Policy Sector (EMR), Parks Canada Program (DOE), Northern Affairs Program (DIAND), and other Departments such as External Affairs Boundary Disputes Program, International Trade.

Within EGM, the following main research tracks are presently identified (see Appendix C:

(a) mineral deposits information base
(b) mineral deposits modelling
(c) regional metallogenic synthesis
(d) mathematical and geostatistical method development and applications
(e) analytical methods development and evaluation.

The Advisory Committee was provided with persuasive evidence of the difficulty faced by individual researchers in responding to the service responsibilities and maintaining an acceptable balance between them and their research.

Most GSC scientists are aware that they work within a world of conflicting functions and priorities that can become counterproductive if they are ignored. On the one hand, the GSC has obligations to deliver advice and service. On the other hand, ensuring that the advice is reliable requires continuing knowledge accumulation and research. At first sight, there is an apparent anomaly in this situation, since there is a commonly held perception amongst individual scientists that although the delivery of service depends on research, service always takes precedence over research in the workaday world. Management pointed out to the Committee that individuals did not always appreciate the extent to which their research time was protected for them.

It was quite evident to the Advisory Committee that the success achieved by individuals in maintaining a high output of quality research depended partly on the amount of administrative and service distractions they faced and the type of studies they were engaged in. However, strength of personality and personal initiative appeared to be as important as talent in determining whether or not research productivity could be maintained. The most productive individuals often display a certain entrepreneurial flair for overcoming bureaucratic delays and distractions and marshalling additional resources to improve their output. They almost always have forceful and confident personalities that enable them to work within a system that appears somewhat constraining and inflexible to an outsider. This observation is important to recommendations that are made later in this report.

CONCLUSION 4.3.1.1 Although performance of the service function depends on research, there is a perception amongst many scientists (but disputed by management) that service always takes precedence over research.

CONCLUSION C4.3.1.2 Personality and initiative are as important as talent in influencing productivity in mineral deposits research within the GSC.

4.3.2 Analysis of research undertaken by individual units

It has already been emphasized that themes guiding mineral deposits research of many individuals are quite distinct from their line functions. The Committee has found it useful to analyze the work of these individuals in terms of these themes, grouping them into a series of units with approximately the same theme. Where the research is closely allied to the service function, the organizational grouping according to service function has been used in defining the unit.

4.3.2.1 Mineralogy laboratory

The EGM mineralogical laboratory serves primarily but not solely as a support group to the various divisions of the GSC. These services include basic mineralogical work,

electron microprobe analysis, scanning electron microscopy (SEM) and X-ray diffraction analyses on a complete range of minerals. The output of this laboratory relates directly to basic research on mineral deposits and their genesis and is best located within EGM.

The equipment available for the above studies is generally state of the art, particularly the new microprobe. The degree of cooperation between this unit and other parts of the division, the rest of GSC and CANMET is very good. Quality of the work performed and turnaround time are excellent judging from the comments from most end-users. There may, however, be a communication problem with some researchers who feel that the facilities are not generally available. It is the Committee's view that the facilities are not being used to their fullest capacity and the laboratory may be somewhat over-equipped for the amount of work being done. More contact within the division, and with other divisions of the GSC may lead to increased use of the facilities.

The facilities of the Mineralogy section of the Mineral Processing Laboratory of CANMET partially duplicate the facilities of the EGM unit. The abilities of the mineralogical researchers at GSC and CANMET are generally considered very good amongst the mineralogical community. In these days of declining available resources and the very high capital cost of new technology it would be advantageous to acquire equipment on a co-operative basis, keeping in mind the direct applications of each group. The acquisition of joint equipment such as the EMR-NRC proposal for a Canadian micro-PIXE analytical facility would lead to 'cutting edge' research being conducted in Canada.

From the standpoint of cost effectiveness of sample preparation it is strongly recommended that polished section production be centralized at CANMET, where productivity per person employed in sample preparation appears to be three times that in EGM. From a cost effective and turnaround time basis the preparation of thin section and polished thin section work would best be done on a contracting out basis.

CONCLUSION C4.3.2.1.1 The EGM mineralogy laboratory is well equipped but is perhaps being under-utilized.

RECOMMENDATION R4.3.2.1.1 The acquisition of large capital equipment items for the mineralogy laboratory, such as the EMR-NRC proposal for a Canadian micro-PIXE laboratory should be undertaken jointly with CANMET and/or other government (both federal and provincial) departments and universities.

RECOMMENDATION R4.3.2.1.2 Polished section preparation be centralized in CANMET and much routine thin section preparation be contracted out, as is the case at present with polished thin sections.

4.3.2.2 Chemical laboratory

The goals of this unit have been:

(i) to provide compositional data for rocks, ores and mineral samples using a combination of classical chemical techniques and instrumental methods. This serves almost solely as a service function.

(ii) Method development for nonroutine samples and new instrumentation.

(iii) Round-robin standard certification.

On April 1, 1984 this unit was transferred to the former Economic Geology Division along with the Mineralogy Laboratory, with the division being renamed Economic Geology and Mineralogy (EGM).

As a support service laboratory this unit has not performed as well in the past as should be expected. This has been due to factors such as slow turnaround time and failure to stay current with modern technology. An examination of projects currently on hand, disclosed some that are two years old, and it has routinely taken several months to obtain results. It is expected that changes within the laboratory which have occurred in recent months will improve matters.

The present facilities are not state of the art, in fact much of the equipment is outdated and in need of replacement. The XRF unit for example, is not computer automated and the crystal used for determining sodium has deteriorated to such an extent that the detection limit achievable is about 1%. There is no question that the GSC requires a laboratory that is equipped with state of the art equipment and staffed with people specialized in the use of this equipment. The recent acquisition of a simultaneous ICP unit is a step in the right direction, although ICP should have been acquired several years ago.

Closer liaison is required between EGM laboratory chemists and mineral deposit geologists in order to define more clearly the requirements of the studies. The type of service work undertaken by this unit should relate to method development work required for solving specific problems originating within individual projects. Large numbers of routine samples should be contracted out to commercial laboratories which can provide excellent analytical results at a fraction of the cost with a faster turnaround time than a government laboratory. The management and quality control monitoring of the contracts should be the responsibility of the staff of the chemical laboratory rather than the scientists requiring the data.

Careful consideration should be given to the introduction of an internal realistic costing system based on 'real' costs, with the research customers 'buying' their results from the internal laboratory. While the amount of time expended on producing an invoice for internal purposes is negligible, it will bring a far greater degree of accountability to the system.[1] Development work on methods could be funded through allocation of funds to particular development projects and not in a blanket fashion.

CONCLUSION C4.3.2.2.1 The EGM chemical laboratory is outdated and is overstaffed for the amount and type of work being done.

RECOMMENDATION 4.3.2.2.1 The EGM chemical laboratory should be modernized with the acquisition of state of the art instrumentation and appropriate support personnel.

RECOMMENDATION 4.3.2.2.2 Routine sample analysis should be contracted out to commercial analytical laboratories, with the contracts being managed and monitored by the staff of the chemical laboratory.

RECOMMENDATION R4.3.2.2.3 That a realistic costing of internal analytical work be instituted with costs to be paid out of 'paper funds' allocated to the budgets of individual projects.

4.3.2.3 Applied chemical laboratory (Resource Geophysics and Geochemistry)

This RGG laboratory was set up a number of years ago as a result of the former Central Laboratories and Technical Services Division's inability to respond to new need. This need was to provide rapid analytical results not requiring a high degree of precision. Basically RGG did not require analytical precision greater than the sampling variability for the research they were conducting, and rightly so.

[1] Many universities have had to introduce a system of this kind so that individual NSERC operating grants pay some or all of the costs of their increasingly sophisticated laboratories. In cases known to members of the Committee, the extra accounting involved takes one or two people no more than two or three hours per week.

This results in a class of analysis termed 'geochemical' by the analytical industry as opposed to the assay techniques used in the EGM chemical laboratory.

In general the laboratory has operated with four main thrusts:

(i) Analytical methods development for exploration geochemistry
(ii) Analytical instrumentation testing and development
(iii) Contracting out routine large volume analytical requirements
(iv) Geochemical reference standard preparation and certification.

The above aims have largely been successfully achieved with a minimum number of personnel. The equipment available within this laboratory mainly does not duplicate that of the EGM chemical laboratory with the exception of atomic absorption spectrophotometry instrumentation and sample preparation facilities.

The future delivery to the RGG laboratory of a newly developed (by a Canadian company) inductively coupled plasma-mass spectrometer will allow for 'cutting edge' research into the development of trace and isotope analyses and their possible application to mineral exploration technology. The recent delivery in this laboratory of a conventional sequential ICP unit, while not providing the same 'cutting edge' research potential (the instrumentation is not a newly developed technique), can also be of benefit.

Between the EGM and RGG laboratories there are still obvious gaps in instrumentation and thus gaps in the potential for mineral deposits research. An example is the lack of a gas chromatograph-mass spectrometer for studying emanating gas haloes around ore deposits. This field of research is again 'cutting edge'

This committee investigated the possibility of combining the RGG laboratory with the EGM chemical laboratory. It is recommended that the EGM chemical laboratory be given time to adjust to its new situation in EGM before this is re-assessed. Once the updated methods and procedures are working well a further review of a possible combination should be undertaken, perhaps in two years.

CONCLUSION C4.3.2.3.1 The RGG chemical laboratory is progressive in nature and generally is run efficiently, partly because of its close involvement with research into and the development of techniques.

RECOMMENDATION R4.3.2.3.1 After allowing a two year period for the EGM chemical laboratory to adjust to its new situation, a study should be undertaken to determine whether the RGG laboratory should be combined with the EGM chemical laboratory.

4.3.2.4 Mathematical Applications in Geology

This section has three objectives:

(i) to develop and apply probabilistic methods of resource estimation for land-use planning;
(ii) to provide a mathematical and statistical consulting service throughout the GSC;
(iii) to develop statistical exploration methods for use by the mineral industry.

This unit is composed of two research scientists although the organizational chart suggests that there are four individuals. The role of the other two people will be discussed under the Data Interpretation Unit. Although the Committee concluded that the geomathematical group is highly regarded by its peers, they were uncertain as to the role of this unit and where it belongs in the organization. It is estimated that about 50 per cent of their work is within EGM. At the present time, the Committee does not recommend any change in organizational position.

It appears that since 1981 there has been a more conscientious effort by the group to interface more directly with the geoscientists within EGM. Further integration and co-operation should still be one of the main objectives of the group. Taking part in integrated projects, producing papers jointly with other groups in the division, and compiling a list of available computer programs for mineral deposits research with adequate description and documentation should be encouraged.

The group as a whole, has a very positive attitude and hopefully will aid greatly in applying modern statistical and data processing techniques to research in mineral deposits.

CONCLUSION C4.3.2.4.1 The mathematical applications group is highly regarded, however it appears to be under-utilized by the rest of the GSC.

RECOMMENDATION R4.3.2.4.1 The mathematical applications group should try to narrow the gap between its state of the art work and the work of colleagues in the GSC and integrate more closely into the various projects within EGM.

4.3.2.5 Data Interpretation Unit [1]

A major portion of the time of the two individuals of this unit is utilized in activities which the Committee would term as "Data Interpretation". Clearly this group could also function in some other Division, e.g. RGG Research topics such as biogeochemistry from space, regional geochemistry numerical analysis, and objective lineament analysis are fairly new at the GSC. They represent exciting developments, of much promise to industry and to provincial governments. It is important that the GSC keep the provinces and industry aware of these developments to avoid possible duplication of effort.

Canada has devoted much time, effort and money to ERTS/Landsat programs, but the mineral deposits area has received little benefit of any practical use because of difficulties in interpretation related to tree cover, forest burn areas and Pleistocene deposits cover. Hence the proposed study of "stressed vegetation assessment from space" is an exciting one, with possible application to mineral deposits exploration throughout Canada.

Federal and provincial governments have put many millions of dollars into regional stream/lake geochemistry throughout Canada (the National Geochemical Reconnaissance Programme). These surveys have been favourably received by much of the mineral industry. Historically a specific decision was made to present data only and not sophisticated interpretation. It was argued correctly, that the former suited the competitive needs of industry, and the latter would have been a case of 'running before having learnt to walk'.

Now that much detailed follow-up has been done, the original data (analytical values), are capable of more comprehensive interpretation; also sophisticated regional interpretation techniques have evolved elsewhere e.g. (US Geological Survey, British Geological Survey and in some Canadian industry groups). It seems an appropriate moment for the GSC to become re-involved in this area via a geologist-geochemist-mathematician.

There is a growing emphasis on the structural control of mineral deposits due to demands of gold exploration and precious metal vein systems etc.; thus an objective

[1] Ed. note: Part of the Mathematical Applications in Geology Section.

assessment of lineament analysis of ERTS/Landsat data, is also a worthwhile and timely area of research, which will be closely monitored by industry.

These three topics may well evolve from 'cutting edge' to routine, 'run of the mill', service functions; at that point the GSC should seriously consider contracting out interpretative technology to 'production-line industry', so as to avoid becoming bogged down with routine.

CONCLUSION C4.3.2.5.1 The work of the data interpretation unit represents an exciting development of much promise to industry.

RECOMMENDATION R4.3.2.5.1 Amongst its programs the data interpretation unit should concern itself with the evaluation of data generated by RGG using or adapting the sophisticated regional interpretation techniques that are employed in other countries.

4.3.2.6 Inventory files

The Mineral Resource Information Services unit, comprising five individuals, has responsibility for all commodity and metallogenic files, and the maintenance of local library and reference services within EGM. The main data file within this unit is an extensive computer-processable mineral deposit data file called CANMINDEX. The activities of this unit were looked at in only a superficial manner and it is impossible to analyze its work in any detail. However, some general comments are warranted.

The quality and relevance of CANMINDEX are not easily determined, although they are reportedly quite good. This is primarily because it is an internal file that is not readily available to the public or researchers outside EGM. Although the National Mineral Inventory, which is maintained separately by a unit within the Mineral Policy Sector of EMR, serves as a basic data source for CANMINDEX, the two files were developed for different purposes, have evolved with different formats and are growing in different directions. In addition, there appears to be inadequate interface with provincial files and no recognition of the potential or usefulness of exploration-oriented files prepared commercially by industry.

Representations to the Advisory Committee indicated a strong consensus that collection and storage of data on all mineral deposits in Canada is a federal role, including co-ordination and compilation of files. There is concern about the number of federal files, the current lack of co-ordination and the obvious duplication of effort. As well, there are some questions about the most economical way to collect the data and make them avilable.

The Advisory Committee understands that this whole subject will be reviewed in detail at a National Workshop in Toronto in March, 1985.

The Advisory Committee strongly endorses the principle that mineral deposits data should be collected on a co-operative basis from the provinces and territories by the federal government. It does not hold firm views on where the file should reside as long as consistent quality and compatible formats are maintained between different regions and files. As well, all federal files should be integrated into one computerized file and the non-confidential information in it should be made telephone-accessible by the general public.

RECOMMENDATION R4.3.2.6.1 All mineral deposits data should be integrated into one computerized file and the non-confidential information in it should be made telephone-accessible by the general public.

4.3.2.7 Deposits in mafic and ultramafic rocks [1]

This unit is composed of four individuals who have had wide experience and who together bring a familiarity with phase equilibria and mathematical modelling as well as standard petrology to their studies.

Apart from research on the well-known associations of mafic-ultramafic rocks and nickel, nickel-copper, asbestos, etc., this group has recently focussed its research attention on chromium and platinum group elements (PGE).

Resources of chromium and the platinum group elements (PGE) are concentrated in those parts of the world that are susceptible to political disruption and from which an uninterrupted supply cannot be guaranteed. Individuals with experience in exploring for these metals, and with a familiarity with their common host rocks (mafic and ultramafic rocks) are not widely available to most mining companies. The Shield, and the Appalachian and Cordilleran fold belts of Canada contain numerous bodies of mafic and ultramafic rock which, thus far, have not yielded significant concentrations of chromium or PGE. It is likely that exploration for these minerals will intensify and it is appropriate that the GSC has the expertise available both to develop concepts to guide exploration, and to advise explorationists who ask for it.

The unit has recently doubled in size. The original members have a reputation for high quality, innovative work. The new members have similar reputations from their work elsewhere.

The past work of members of this unit has not been interfaced well with other studies of the GSC. Most mafic and ultramafic rocks are either an integral part of the magmatic development of an area, or are associated with major tectonic structures. As such, they should be studied in conjunction with the large mapping projects undertaken by GSC or by provincial agencies that focus on different terranes in Canada. For example, in the mapping Project being carried out by the Quebec Government in the Cape Smith – Wakeham Bay and adjacent circum-Ungava belts, the ore deposits associated with the ultramafic rocks of these belts should also be studied. Some members of this unit would be obvious candidates for a study of this kind if the provincial government believed that their participation would be beneficial.

With regard to short-term communication, members of the unit have been effective in presenting their ideas and representing the GSC at conferences and workshops on their subject. The Committee believes that the productivity of the unit should be increased by the recent influx of new blood.

4.3.2.8 Deposits associated with felsic rocks [2]

Currently EGM has only one individual covering this deposit-type, for all of Canada. Since so much Cu, Mo, W, Sn, Au mineralization is related to felsic intrusions, the relevance of this unit is considerable and thoughtful and thorough documentation and detailed assessment of mineralization associated with felsic intrusions in the Canadian context will continue to be important. Past and current programs appear to be of reasonable quality. The person working in this area has made constructive efforts to contract out certain definable areas (isotopes etc) to interested university groups, and to involve both mine geologists to ensure relevance and provincial geologists to give a regional context.

---

[1] Ed Note: Composed of individuals in Mineral Deposits Geology and Regional Resource Assessment sections.

[2] Ed. Note. EGM has the full time efforts of one scientist (Mineral Deposits Geology Section); however other scientists within EGM as well as other Divisions (eg. RGG, PG) are working in this area of research.

It is not apparent whether there is much interface outside of EGM, e.g. with felsic igneous petrologists or with isotope specialists in the GSC.

The final publications appear to be of good quality, are timely, and involve relevant industrial and provincial colleagues.

This is clearly an area which needs strengthening, possibly by co-operative programs with provincial surveys, many of whom have considerable expertise in granitoid hosted mineralization, especially in the Appalachians and the Cordillera.

4.3.2.9 Gold in Greenstone Belts [1]

In a country that is known as one of the world's leading producers of gold, and has vast resources in gold, relatively few scientists appear to be working full time on gold-related projects at the GSC. This situation may have developed historically, due to the fact that gold producing districts and, to a lesser extent, former gold producing districts, have been the centre of attention of the provincial surveys and of the provincially funded universities since the early 1970s.

EGM now has two relatively junior researchers working on gold: one in the south central shield and one in the Northwest Territories [2]. Soon (government restrictions permitting), there will be the addition of another junior metallogenist specializing in gold deposits of the Abitibi Belt of northwestern Quebec and northeastern Ontario (Cadillac Break) [3].

With the number of gold camps presently in production in Canada and with those due to open up soon (e.g. Hemlo camp in Ontario), the Advisory Committee feels that two or three metallogenists working part time on gold (silver) deposits is not adequate to develop and maintain mineral deposits expertise on a national basis and to contribute basic geological and metallogenic information to the mineral industry. The committee believes that a critical mass has yet to be achieved in this area. It also has some concern as to the present degree of communication.

So far, the two members of the unit working on Archean gold deposits have demonstrated their ability to communicate on a short term basis (GSC Current Research volumes, Abstracts, etc.). It is hoped that more substantial publications in the GSC series or in refereed journals will come forth within the next year or two.

4.3.2.10 Massive sulphide deposits [4]

The study of massive sulphide deposits became very popular in Canada in the 1960s and 1970s. By now, every onshore massive sulphide deposit and every enclosing volcanogenic belt, intrusive complex or sedimentary basin has been described, compiled and researched by geoscientists employed by private companies, by research institutes and universities, or by provincial and federal surveys.

Interesting research is presently carried out by the GSC in this field on the Pacific seafloor at the site of the Juan de Fuca and Explorer spreading ridges. Unfortunately, the scientists involved in this project are also actively involved in several other studies, as well as having other responsibilities.

The Pacific seafloor study is currently relevant and is likely to remain so. Considering the early stage of the project, the high cost, and the technical difficulties usually associated with the study of geological phenomena on the seafloor, it is too early to assess the quality of the work carried out so far.

Because this project is in a class by itself, it does not seem to liaise with other research functions or projects, although its funding is provided partly through the three year (1984-86) special Departmental initiative on Boundary Disputes administered by Pacific Geoscience Centre, Atlantic Geoscience Centre and partly (minor) through EGM A-base program (see Appendix C).

Communication of the results is adequate, due mainly to the high enthusiasm of the scientists presently involved in the seafloor project. The dives and the research are carried out in close co-operation with university faculty.

With the large budget of this project, the division management should make absolutely sure the GSC scientist in charge is not unduly diverted by service function activities which could be administered by someone else. Otherwise, despite the allocation of a high level of funding to one of the most interesting research projects in the earth sciences at the GSC in recent years, there may be relatively little to show for it.

RECOMMENDATION R4.3.2.10.1 That, because of its mineral deposits research opportunities, the Pacific offshore study warrants a sustained, collaborative research thrust.

4.3.2.11 Clastic sediment hosted deposits

This group comprises four scientists specializing in lithogeochemistry and hydrogeochemistry, sedimentology, stratigraphy and ore deposit genesis and modelling. Because of the breadth of their research interests, they are not easy to classify as a group and this title describes only the most important common component of their work. The activities of this unit comprises a vital part of the GSC work on mineral deposits research. Three members of the unit have devoted most of their research to the Cordillera but one has only been with the Survey for a year; the fourth is active in the Canadian Shield.

Viewed world-wide, shale hosted sedimentary-exhalative (sedex) deposits of Pb, Zn and Ag are an extremely important class. Although the Sullivan deposit is one of the major type examples, this deposit type received relatively little attention throughout much of Canada from an exploration viewpoint until attention was focused on the Selwyn basin in the past 15 years. From a research point of view, Canada's involvement has been 'rather little, rather late'. This unit has provided only a small part of Canada's research contribution in this area until recently. The quality has been high. A positive aspect of their work has been the high degree of interface between those involved in regional mapping and those involved in detailed study of deposits. The Committee found this a refreshing change from the 'deposit hopping' that characterizes much GSC mineral deposits work.

The members of this unit have an enviable publication record and have proven themselves effective communicators as well. Their participation in technical meetings and poster showings is commendable and their rapport with industry is very good.

4.3.2.12 Uranium deposits [5]

This group originated from, and is sustained by, a Departmental (EMR) Policy directive with regard to the strategic national role of uranium resources and is a part of

---

[1] Mainly scientists in Mineral Deposits Geology, Regional metallogenic studies and mineralogy sections.

[2] Ed. note: In addition, several other scientists in the Division have part-time responsibilities in gold.

[3] Ed. note: This staff member was appointed Jan. 1, 1985.

[4] Ed. note: Mainly Mineral Deposits Geology and Regional Metallogenic Studies sections.

[5] Ed. note: Part of Regional Mineral Resource Assessment Section.

the Uranium Resource Appraisal Group (URAG) mandate. The geological component of URAG is to provide estimates of resources additional to reserves in established districts and camps, to develop working genetic models, and to assess frontier areas for uranium potential.

Over $100 million a year was spent in the period 1978-82 on uranium exploration in Canada, hence URAG grew quickly to become a large group administering the law and influencing exploration. These tasks are clearly service functions that give little time for research, and the group became well known for deposit hopping.

Uranium exploration has now declined to about $40/million a year, mostly in the advanced drilling of known mineralization, and there are moritoria in effect in British Columbia and Nova Scotia, and a ban on development in Newfoundland/Labrador. Thus this group needs to be, and is being, wound down.

However, the legal responsibility is still there and a core group, probably of two persons, will be needed to monitor, compile, synthesize and publish, in a lucid format, what they have learnt, especially of the metallogeny of uranium in the Shield, the Cordillera and the Appalachians. Thus, if and when uranium returns as a desired commodity, the necessary basic data will exist in an accessible, hard cover format. Clear goals for this format, and a deadline for publication within five years should be established, and this compilation should be completed now, in the quiet years. The format and output should be a co-operative/collaborative program with the provincial governments.

As explained above, this group has had little time for research and indeed little was attempted. Relevance of such research is now relatively low, but continued efforts on a restricted scale will provide a useful springboard if and when uranium exploration intensifies.

The quality of the research achieved by the group has been uneven with strong points including the study of the genesis of the southern British Columbia deposits, the compilation of the Saskatchewan unconformity deposits, and observations on mineralization in the Northwest Territories.

The uranium commodity group highlights the problems that can develop when the service function totally dominates a mineral deposits group. The output becomes scattered and uneven without the clear guidelines of a focused research goal.

RECOMMENDATION R4.3.2.12.1 That, in view of the declining importance of uranium exploration and the desperate need for additional personnel to work on other deposit types, the uranium group be reduced from three to two and that the remaining two be strongly encouraged to produce a compilation and synthesis of the findings of the whole group over the past 12 years in a hard cover format within five years.

4.3.2.13 Theoretical modelling of deposits [1]

This unit, consisting of two persons, has experience in modelling both moderate temperature (300-400°C) hydrothermal deposits and evaporite sequences.

If undertaken in conjunction with field-based studies of other GSC scientists, this work can provide the theoretical basis that will add confidence to suggested genetic models. It can also provide a predictive capacity for undiscovered deposits, based on signs that the process of ore formation has imposed on the bedrock environment. It could, therefore, be very relevant.

Relevance requires, however, a focus on deposits of the moment, rather than those of the past. The Committee is concerned by the apparent concentration on evaporites, shale-hosted deposits of the Selwyn Basin, and volcanogenic deposits of the Noranda area. Seven or eight years ago it could have been argued that these were of current interest. A terminal five year project initiated at that time would have been relevant. The same argument does not apply today. It is disappointing to find an apparent lack of interest in becoming involved at the present time in the Juan de Fuca ridge project. The expertise of both members of the unit could provide valuable input into this project now, defining problems, influencing sampling and making preliminary studies on the samples to guide further sampling. If involvement does not start in the early stages, there is the danger that others will make the important decisions, and that the opportunity for meaningful input from members of the unit into the guidance of the project will be lost.

The amount of work published by the unit over the last seven years is relatively small. Explanations include the unavailability of analyses and secondment to other projects. Some of the work that has been produced is of outstanding quality.

On the short term, there has been reasonable success in communication at conferences and workshops. However the theoretical nature of the work means that verbal presentations often can do little more than advertise the work, which must then be assimilated from printed copy. Every effort should be made by the group to publish their important concepts as quickly as possible.

CONCLUSION C4.3.2.13.1 The theoretical modelling group are working on projects which, when initiated five to seven years ago, were relevant, but which have become less relevant with time.

RECOMMENDATION R4.3.2.13.1 The theoretical modelling group should concentrate more of its efforts on ore deposits of current interest (e.g. seafloor, Archean gold) and its members should become attached to teams working on these deposits at an early stage, so that they can provide input into the collection of the data.

4.3.2.14 Commodity specialists [2]

Four individuals can be identified who still fulfil this classic service function. In theory, the work is underpinned by some level of research, so that the individuals have an understanding of the deposits which contain their commodity.

The presence and evolution of commodity specialists is a historic development, a response to situations such as the OPEC crisis of 1973, which prompted a policy requirement to tabulate what commodities Canada might face strategically important shortages in supply [3]. Hence for each element (commodity) there is a requirement to document where it is, how much is there, what it is associated with and, very much as an afterthought, why it is there.

The first three criteria are not in competition with the universities because clearly they are not research. Originally there was also little conflict with provincial governments, which did not want to build up complete commodity staffs themselves. The provincial desire was for the data to be released quickly in a useable format; unfortunately this often failed to happen. The provinces were often forced to hire their own commodity experts for the three following reasons (a) because the GSC had no suitable expertise, -e.g. industrial minerals; (b) because local demand for information was high,

---

[1] Ed. note: Mineral Deposits Geology Section.
[2] Ed. note: Mineral Deposits Geology Section and Special Projects.
[3] Ed. note: The commodity approach evolved in GSC many years before OPEC and was a response to the Department's needs to maintain an overview geological expertise on Canada's principal trade minerals.

eg. potash in Saskatchewan; or (c) because confrontation over mineral policy with the Federal government meant that the provinces wanted their own independent data sources and expertise.

The commodity specialists were not in competition with industry, which, on the whole, welcomed the usefulness of a set of publications detailing the where, how and why of selected commodities in Canada.

Within EMR, however, three groups developed with much overlap but only a limited amount of co-operation and collaboration. The Mineral Policy Sector developed its team of commodity officers (many of whom are geologists); hence their publications often have a high geological content. Within the GSC, EGM attempted to cover most commodities; currently the four remaining specialists that we identify cover eight commodities: Pb, Zn, Fe, Mn, Ag, Au, Cu, Mo. At the same time, within RGG, a few individuals began publishing volumes devoted to silver in Canada, gold in Canada and uranium in the Athabasca district.

Commodity specialists within EGM feel that they have a legitimate research component within their service mandate. As one of their members remarked to us:

> "they try to generate meaningful research ideas out of their service responsibility and thus keep commodities in the main stream of the mineral deposit research, and leave the economic and statistical commodity overviews to the Mineral Policy Sector".

The remaining geological function of the commodities group within EGM is to produce a set of national commodity metallogenic maps and the final volumes on their eight commodities.

Although commodity projects have been carried on for some time, the Committee found it difficult to fathom what the objectives of the research component has been and hence what the relevence is. In general, the Committee believes that much of the commodity approach to research has not been as productive as that in other areas. It appears that some staff have produced diverse publications while they have held a commodity portfolio, but very few in the field of their commodity. Meanwhile, some scientists appear to have been so overwhelmed by the complexity of their commodities that they have published little in recent years.

Some of the work of this unit has been of outstanding quality and the publications are the standard references in the field for Canada. However, too much of the commodity work remains unpublished or is in the nature of data files without synthesis and interpretation. We hope final works will soon be forthcoming and will be of the quality that the unit has achieved in the past.

CONCLUSION C4.3.2.14.1 The commodity approach to research has not been overly successful within EGM.

RECOMMENDATION R4.3.2.14.1 Scientists who still function with a commodity approach to their research should be re-assigned to other projects. Those who have yet to produce comprehensive reviews of their commodity(ies) should be given a period of two to three years in which to do this before taking up new assignments.

4.3.2.15 Regional metallogeny

This unit is perceived as being composed of four scientists, although others are included by the GSC itself as participants in this field. It is the view of the Committee that these others had been included in the GSC chart for administrative convenience rather than functional reasons and that these individuals are, in fact, engaged primarily in activities that are not regional metallogeny. One of the four regional metallogenists is presently engaged in a purely administrative function with no time for research. The opportunity for research available to the others and the best methods and location for conducting research on this subject were the topic of considerable debate within the Committee.

The Committee had mixed views on whether the type of work performed in the past was more of a research or a service function. Looking to the future, two alternatives appear to exist:

(a) that regional metallogeny will be a legitimate and important research and service function within the GSC; or

(b) that the GSC will restrict its metallogenic effort to national co-ordination and to more detailed, integrated studies in connection with deposit-type or regional mapping programs, as is discussed below.

There is a perception in industry that the quality of the work performed by individuals in this group is variable. The committee concluded that research goals have not been set clearly and that performance has not been well monitored. The publication record has been disappointing and this has led to members of this unit developing a reputation for 'deposit hopping' and for collecting but not disseminating data.

If this unit is to continue to exist and to achieve success, the research goals must be defined much more clearly. The committee believes that the present system of assigning an individual metallogenist to a broad area will not be successful. They stress that the interfacing of metallogenists with other geologists in co-ordinated projects concentrating on specific structures or transects of structures, as is already being done to a limited extent, is more likely to achieve worthwhile results.

4.3.2.16 Concluding remarks

The overall quality and productivity of individuals engaged in mineral deposits research varies widely. Some of the work is of the highest calibre and is equal to that undertaken anywhere in the world. Much of it is sound and worthwhile and has contributed greatly to our understanding of Canadian ore deposits and their settings. However, a proportion of the research scientists contribute relatively little to the world of science. Overall the Committee is disappointed that scientists engaged in mineral deposits research have not achieved, as a group, the leadership in their field that their critical mass and association with one of the world's most respected geological surveys should have enabled them to achieve.

As indicated earlier, many of the research topics are bottom generated and then continue with little managerial supervision. Superior scientists can function effectively in this environment (often this is the only environment in which they will be fully effective) although they are hampered within the GSC by the lack of junior collaborators. Lesser scientists are not able to work in an effective manner.

In the universities, the five- to six-years probation period before the granting of tenure and the one, two or three-year review of quality and productivity that is provided by the NSERC peer evaluation are reasonably effective monitors of quality with the result that the less capable researchers tend to be either eliminated from the system or shunted out of the research stream. Tenure within the universities undoubtedly contributes to the presence of faculty who no longer pull their weight in research, but the five to six years that exists before it is granted means that it is easier to identify those with potential shortcomings than it is with the twelve-month probation of the Public Service Commission of Canada. Despite the internal peer review system that operates within the GSC, there appears to be

relatively little that can be done about an ineffective researcher once he is identified. Competent and less competent researchers alike appear to be relatively free to develop their own projects. The Committee concluded that this approach has resulted in a dilution of overall quality. It is recommended that an effective mechanism be established whereby those scientists who are not competing effectively in the research stream be removed from this stream and identified as contributing to other aspects of the GSC. The Committee realizes that mechanisms, including the reduction of funds for projects, are already employed in these situations but concludes that they are not particularly effective.

CONCLUSION C4.3.2.16.1 In a research environment where research topics are generated by individual scientists, superior scientists function well but lesser scientists are not able to work effectively. Some scientists engaged in mineral deposits research are in the second category due to the shortness of their apprenticeships and the absence of an effective method of ensuring their response to periodic assessments of their progress.

RECOMMENDATION R4.3.2.16.1 That a mechanism be established whereby those scientists who are given a poor assessment on the basis of their research activities be removed from the research stream and identified as contributing to other areas.

5.0 FUTURE MINERAL DEPOSITS RESEARCH

5.1 Mechanisms for setting objectives

5.1.1 The Problem

Research objectives in the GSC are currently in a state of revision and review, prompted by the development of new strategic 'thrusts' (policy goals) at the departmental (EMR) and cabinet level. Amongst these is a Mineral Research thrust within the Earth Sciences Sector of EMR that consists of both exploration technology and mineral deposits research components. The former falls largely within the mandate of RGG and perhaps CANMET and lies outside the scope of this review. Implementation of the new policy will require a management system within the GSC that does not presently exist.

The lack of such a system for defining the objectives of mineral deposits research, for choosing between the many alternatives and for measuring the effectiveness of the research is perceived by the Advisory Committee as the most serious problem it encountered in its review. Written responses to its questionnaire showed that this concern was shared by more than 95 per cent of the respondents in each of three sectors polled (governments, universities and industry). In addition, it appeared to be shared by virtually all the scientists and managers within the GSC who were interviewed by the Committee.

The choices available for mineral deposits research in Canada are both exciting and complex. In addition to the question of selection of commodities, deposit types and environments for study, there are many other alternatives to be weighed. Should the commodities of which Canada has an abundance be emphasized or should those commodities in which Canada is apparently deficient receive mass emphasis? Perhaps the latter group has not been explored for hard enough? How much relative effort should be assigned to the various research categories such as modelling, improving the information base, and developing improved analytical methods? There are also strategic, regional and social policies to be considered.

At present, mineral deposits research choices within the GSC are made in an ad hoc fashion, depending on the current interest of its resident scientists and managers and their individual responses to lobbying by those outsiders they communicate with, as well as to political pressures. The Advisory Committee regards this approach as clearly inadequate to fulfill national goals in mineral deposits research.

In searching for solutions, the Committee was mindful that the problem is complex and includes the following elements:

- there is a need for both improved internal and external technical planning and accountability.
- the internal system must involve cooperation between individual researchers and coordination with top-driven government-wide priorities.
- a new system of decision-making within the GSC should simplify and replace rather than augment the already heavy administrative burden to avoid further erosion of research time.
- the service role of the GSC could be strengthened by ensuring that the fields of research undertaken more closely reflect the needs of the industry and the nation.

CONCLUSION C5.1.1 The lack of a system for defining the objectives of mineral deposits research and for evaluating research effectiveness is the single most serious problem with respect to mineral deposits research within the GSC.

5.1.2 Suggested Solutions

5.1.2.1 Internal

It is recommended that management establish an internal planning group, composed largely of research scientists, who will receive advice from both inside and outside (see below) EMR and set research policies and objectives. Individual scientists should be required to work within this framework on co-ordinated projects, with pre-set goals to be achieved within a specific time-frame.

RECOMMENDATION R5.1.2.1.1 That management establish an internal advisory group which will set research policy and objectives.

5.1.2.2 External

The Advisory Committee concluded that the interface and communication of management and many of the scientists of units engaged in mineral deposits research with the community of external users of the research has been unsatisfactory. In searching for a solution to the problem of obtaining input as to the needs and views (in order of priority) of industry, the provincial and territorial governments, and the universities, the Advisory Committee became aware that a workable model already exists in CANMET. This is an external advisory body created by an Order in Council to advise the Minister on the appropriateness of CANMET's program. It is called the National Advisory Committee on Mining and Metallurgical Research (NACMMR).

This Advisory Committee recommends the establishment of a permanent National Advisory Committee on Mineral Deposits Research (MINDER?) that would advise the Minister of State (Mines) through the Assistant Deputy Minister, Earth Sciences Sector, on appropriate fields of research within this sector, including the GSC. MINDER would also review program plans with senior management and monitor performance annually, as well as solicit and co-ordinate views on the subject from the geoscience community outside the Survey. In order to represent the interests of all those involved in mineral deposits research MINDER should be structured as follows:

- it should consist of about eight to ten members and include senior geoscientists chosen from names suggested by industry, provincial and territorial governments and universities;
- it should include a strong representation from the provincial governments in recognition of provincial jurisdiction over mineral resources;
- it should contain a mix of both researchers and users of the output;
- it should have a broad geographic representation;
- where possible, members should be familiar with the structure and operation of both industry and government, and should have demonstrated a reputation for leadership and an understanding of the organization of the geoscience community;
- members should serve for no more than three years on a rotating basis and should receive travel expenses. Where appropriate, an honorarium for time spent on the work MINDER should be available for individuals who are not employed by large organizations.

RECOMMENDATION R5.1.2.2.1 That a National Advisory Committee on Mineral Deposits Research be established, composed of eight to ten senior geoscientists representing provincial and territorial governments, industry, and universities, to advise the Minister of State (Mines) through the Assistant Deputy Minister, Earth Sciences Sector, to review plans for research programes, monitor performance and co-ordinate views on the subject from outside the GSC on an annual basis.

5.2 Methods of achieving objectives

5.2.1 The Problem

The Advisory Committee concluded that the failure of the GSC to achieve pre-eminence in mineral deposits research in Canada stems from the past attitudes of management, coupled with constraints inherent in the Public Service system. Some of these are:-

(a) The Committee received the strong impression that management has tended to regard mineral deposits scientists, as a group, as being of lesser importance than those of other disciplines.

(b) Management regarded the time allocated to research as necessary to ensure that the best possible people were attracted into and kept in the division for the purpose of performing their service function. While recognizing that good research is essential to this goal, past management was not particularly concerned with the focus or eventual end product of this research.

(c) The present method of measuring accountability is to have each individual scientist set out his goals for the year and have these approved by his superior. The scientist's success in achieving these self-set goals is then assessed. The Committee regards this as likely to promote 'apparent' rather than 'real' productivity.

(d) As emphasized previously, the confirmation of permanent employment after a probationary period of 12 months means that the process of 'survival of only the fittest' is suppressed within the GSC, as in all government organizations.

The Committee has found that research is considered by both scientists and management as taking up an average of about 50 per cent of each scientist's time. Thus, in the Committee's view, there has been insufficient emphasis and effort in focussing approximately 50 per cent of the person-years engaged in mineral deposits studies.

5.2.2 Some suggestions as to solutions

5.2.2.1 Research functions

The Advisory Committee believes that a major re-orientation of thinking is required on the part of management. There are a number of signs that this has already started; in fact the striking of this Committee is one of them.

If management accepts that the research function of an individual can and should be just as important as his service function, and if management in general can achieve an integration of research focused on some clearly defined objectives of high priority along the lines of those outlined in this report, the Committee believes that the GSC will become an excellent environment in which to conduct mineral deposits research.

An improvement of the type that we suggest must involve the efforts of both scientists and management. The scientists must give up some autonomy over their research and management must provide leadership and recognition. The benefits coming to individuals from accepting and working within the philosophy of a planned approach should be emphasized. Those who consistently fail to meet their goals should be shifted out of research and used in other roles that consume less of the already scarce field, travel and laboratory budgets. Accountability for time spent on research should become a dominant theme within groups working on mineral deposits research; in this context, accountability implies the obtaining of high quality results bearing on defined objectives and their dissemination to the public within a specified time.

RECOMMENDATION R5.2.2.1.1 That GSC management go on record as recognizing that performance in the research function is equally important to that in the service function for the advancement of an individual's career, and to achieving the goals of the GSC. Thus, on average, 50 per cent of an individual's time should be devoted to research.

RECOMMENDATION R5.2.2.1.2 That management institute a planned approach to mineral deposits research, following plans set by an internal advisory group, and that individual scientists be required to work within the outline of this plan, achieving and publishing results within a pre-set time frame.

5.2.2.2 Service Functions

The present structure of the organization relies heavily on the service function rather than the research function. The prime function of a government line agency is to provide service to other government programs and departments. To deliver this service function effectively there must be accumulative acquisition of knowledge which depends to some degree on research.

The following service functions are currently recognized within EGM (Fig. 4.3):

(1) Regional Metallogenic Studies
(2) Mathematical Application in Geology
(3) Mineral Deposits Geology
(4) Regional Mineral Resource Assessment
(5) Mineral Resource Information Services
(6) Laboratory and Scientific Support
(7) Mineralogy Laboratories
(8) Chemical Laboratories
(9) National Collections and Curatorial Services
(10) Sample preparation

All of these units are principally organized and operate as service functions. While recognizing the importance of the service function, a division of some of the service tasks into research oriented functions would probably provide an equal measure of service.

It has been suggested that the Mineral Resource Information Service (CANMINDEX) be combined with the economic data base maintained by Mineral Policy Sector, upgraded and computerized to provide necessary geological and economic information which would then be available to government and industry on a pay for service basis.

Laboratory support should be combined (if the work is not contracted out) with mineral separation. Mineralogy and chemistry are at present mainly service functions. The routine parts (e.g. routine chemical analyses) of this service portion should be contracted out and a greater degree of R and D be implemented with greater integration into other research projects.

The Committee felt that some of the resource assessment projects such as park assessments could possibly also be contracted out to industry consultants. This would to some degree free up personnel for more research-oriented projects.

5.3 Suggestions as to the types of studies to be undertaken in the future

5.3.1 The Problem

The point has already been made that mineral deposits research has been characterized by an ad hoc approach to a series of largely unrelated 'bottom-generated' (i.e. suggested by the individual scientists themselves) projects, apparently with little or no defined interaction and time frame. Some individuals have made considerable progress in this environment, but the majority have not fared so well.

Almost all scientists blamed lack of support as one reason for their diminished productivity. At first, the Committee was mystified by this claim since chemical laboratories are available to take care of many of the analytical needs, and a mineralogical laboratory with three microprobes and two SEMs, a consulting mineralogist, an XRD laboratory with expert support, and a data compilation group of five (Mineral Resource Information Service) are available to the scientists.

On delving more deeply into the problem, the Advisory Committee realised that it is not technical support that is lacking so much as junior scientific support. In the universities this need is fulfilled by post-doctoral fellows and graduate students. A scientist at the GSC, working alone on his own self-generated problem, may well be working in comparative isolation.

5.3.2 Suggested solution

The GSC, with its relative stability, large infrastructure, and with its potential for an organized approach to problem solving has opportunities that are not available within the framework of a university. Thus, it can operate far more effectively than other groups in remote areas, sustain operations for long periods, and bring a wide diversity of talent to bear on particular problems.

(1) The Advisory Committee therefore recommends that most scientists be encouraged very strongly to collaborate with their colleagues on multi-faceted approaches to the understanding of ore deposit types, focussing on carefully selected mineral camps. The Committee envisages these projects as involving mapping at both the camp-wide and deposit scale, mineralogical studies of deposits, mineralogical and petrological studies of the country rocks, and fluid inclusion, isotopic and trace element studies of both country rocks and deposits. A type example of this approach (but not the time-frame!) would be the US Geological Survey's study of Creede, Colorado.

Examples of possible targets for this kind of study are Archean gold deposits and the deposits forming on the Pacific seafloor. In both of these cases scientific collaboration with other organisations would be most beneficial. A gold project, for example, would have to involve geologists from industry, several provinces and probably the universities; a seafloor project would have to involve scientists from other federal departments and the universities. With scientists acting as part of a team, the GSC would be contributing a major resource in terms of expertise and money to the project, and would inevitably play much more of a leadership role than if its contribution were restricted to that of one individual. It is this leadership that the community looks for in its national Geological Survey.

Data collected in the course of studies of this kind, undertaken with the active participation of those whose primary interest is to model ore-forming processes quantitatively, will enable very significant modeling to take place with tight field control.

(2) Some of the most important contributions of the GSC as a whole in recent years have come from projects oriented at investigating a specific tectonic – sedimentary – igneous structure. The Wopmay Orogen is a case in point. Many of these projects have had conspicuously little to do with mineral deposits geology, although they have a great deal to teach us in terms of the environment of mineral deposition.

The Advisory Committee therefore recommends that in future mineral deposits geologists with the appropriate expertise be attached to the teams undertaking these regional studies whenever feasible. Much more will be learnt about how mineral deposits fit into regional geology from the interaction of geologists of differing expertise in the field than will be learnt by a regional metallogenist 'hopping' from deposit to deposit and attempting to fit them into the framework of a fold belt for which mapping and interpretation are both patchy and inadequate.

(3) In its questionnaire, the Advisory Committee posed this question:

> "Do you believe that the GSC might have a role to play in locating scientists at certain key deposits? Presumably this would require negotiation at the provincial level and the results of this documentation would be kept confidential for a period of time; the length of this time would be negotiated by EMR and the provincial government and the mining company controlling the deposit".

Of responses to this question, 73 per cent of industry, 77 per cent of academics and 33 per cent of the Mines Ministers were in favour with the balance opposed. Of those in favour, opinion was equally divided between whether this duty was very important or quite important. Essentially no one felt that it fell into the category of "only done if nothing better to do". Many industry respondents pointed out that a program like this should extend through the early stages of mining as well as during development of the property.

This question was prompted by a number of cases in the last 20 years of deposits of great importance, either on account of their size, geologic interest, or both, that were put in production without adequate documentation. The modern trend towards the bulk mining techniques of open pitting, block caving and long-hole stoping means that much of the key geology is destroyed or rendered inaccessible for future study as mining proceeds.

Companies cannot be blamed for this loss of priceless information. Considerations of cost mean that their geologists must concentrate almost exclusively on matters affecting development and production. However, the permanent presence of a government geologist, free from the same constraints and yet working alongside company geologists, would allow careful documentation and study of exposures as they became available.

The reaction of the provinces indicates that many have no wish to see federal scientists encroaching on what they regard as a provincial matter. On the other hand the Committee realises the difficulty that most provinces would face in adding this duty to the others that they undertake. If it is to be done in any kind of a systematic way, it would probably require a coordinated effort on the part of provincial and federal agencies and clearly after negotiation with the appropriate province(s). In this regard, it should be noted that in their responses to our questionnaire, 90 per cent of the provinces and territories said that they wished to develop closer contacts with GSC personnel in undertaking mineral deposits research.

The committee stresses that a program of this kind should not become a form of free consulting. Deposits to be studied should be selected very carefully. Examples of those that might have been incorporated into such a program in the past include the Kidd Creek deposit and the Klondike placer camp.

(4) The GSC has developed a unique expertise in its mathematical geology group. It is desirable to encourage its interaction with other mineral deposits geologists as much as possible. For example RGG has an active exploration geochemical group and there are one or two individuals with similar interests in other divisions. The collaboration between these groups, which has already started, should be encouraged.

RECOMMENDATION R5.3.2.1 That mineral deposits geologists be strongly encouraged to work in teams on projects of finite duration oriented towards the intensive study of a mineral camp containing deposits of a specific type.

RECOMMENDATION R5.3.2.2 That mineral deposits geologists with relevant expertise be attached to GSC projects that are aimed at solving major tectonic – sedimentary – igneous problems of specific structural belts in Canada.

RECOMMENDATION R5.3.2.3 That mineral deposits geologists be located at certain carefully selected 'key' deposits during the development and early stages of mining to contribute to the documentation of the deposits.

RECOMMENDATION R5.3.2.4 That the collaboration between RGG exploration geochemists and EGM mathematical geologists should be encouraged to continue.

5.4 Other comments on operational procedure

5.4.1 Collaboration

It is clear from Section 5.3 (above) that the Advisory Committee recommends that future research thrusts should involve much 'hands-on, team effort' at the modelling of deposits on a regional scale. These activities are likely to be multidisciplinary efforts (c.f. modern ocean-floor geology) and involve teams of geoscientists, often working with scientists from other disciplines. However, Canadian geologists face the additional organizational problem of shared jurisdictional responsibility between the provincial and federal governments.

Thus, any forseeable mineral deposits research project in which the GSC wishes to participate will need the consent of both the province and the mining companies, and their active co-operation. These can only be obtained by making sure, at the earliest possible planning stage, that the program is a fully collaborative venture, in which the terms of reference clearly state: (i) who is providing what money and support, (ii) who is providing what technical expertise, (iii) how, and by whom, is the project being organized, and (iv) what the end-product of the project will be and how it will be published.

Clearly, much of this research could be contracted out to universities, provincial research organizations, and consulting/industrial groups. The roles of these groups and their relationships, responsibilities and reporting functions would have to be clearly defined at the outset.

It was made very clear to the Committee that collaboration, both within the GSC and without, is a problem area; almost all GSC scientists engaged in mineral deposits research are aware of this, and of unnecessary friction that has been generated in the past. Every effort should be made to avoid this friction in the future.

RECOMMENDATION R5.4.1.1 That in planning and executing collaborative projects, every effort be made to respect provincial jurisdictions and the sensitivities of university researcher groups.

5.4.2 EMR Research Agreements, Contracts and ERDA Agreements

GSC scientists are able to influence funding outside EMR in three principal ways; in the use of EMR research agreements, in letting contracts and in participating in ERDA (Economic and Regional Development Agreements). Many of the contracts are designed specifically to achieve the research objectives of EMR staff. The ERDA agreements generally have high budgets and although they involve the participation of others, they have been used by some EMR scientists to assist in achieving their own objectives. Other scientists involved in these agreements seem to have regarded this duty as a nuisance. The Advisory Committee urges that in future every effort be made to achieve mineral deposit research priorities as defined by the GSC through the ERDA agreements.

The EMR research agreements involve relatively little money. Most agreements are for a maximum of $10 000 annually and are usually awarded for projects that are related but peripheral to on-going internal research. The Advisory Committee recommends that these agreements be increased in size and number and that they be granted for projects that are directly related to on-going internal research. For example, they could be used to help finance the participation of academics alongside GSC personnel in the detailed, metallogenetic modelling projects such as those described in Section 5.3.2.

RECOMMENDATION R5.4.2.1 That EMR Research Agreements be increased in size and number, and that they be awarded to promote projects closely related to internal GSC research and in which GSC personnel could be active as opposed to passive participants.

5.4.3 Exchanges with other institutions and organizations

A very positive response was received to those questions in the questionnaire that probed the responsibility of bilateral exchanges between the GSC and university staff and their students and mining companies (see Appendix B). Many academics were keen to see GSC scientists as co-supervisors of their students, wished that their students could visit the GSC for periods of greater than three months, that they could visit the GSC for extended periods themselves and receive GSC scientists into their own laboratories. An equally strong interest in exchanges was shown by industry. The Advisory Committee believes that these exchanges are healthy and recommends that funds and space be earmarked to make them possible. Most hands-on research on the part of GSC staff will have to be collaborative, and if there is no laboratory or office space available for collaborators when they visit the GSC, the collaboration will be less than optimum.

RECOMMENDATION R5.4.3.1 That space and funds be allocated to promote bilateral exchanges for periods of three to twelve months between the GSC on one hand and universities or industry on the other.

5.4.4 Contracting out

The Advisory Committee believes that, in general, government organizations cannot be as productive as industry for routine service work.

Analytical requirements

The need for a mineral deposits research analytical laboratory (or laboratories) exists within EGM. The function of the laboratory should be the development of analytical

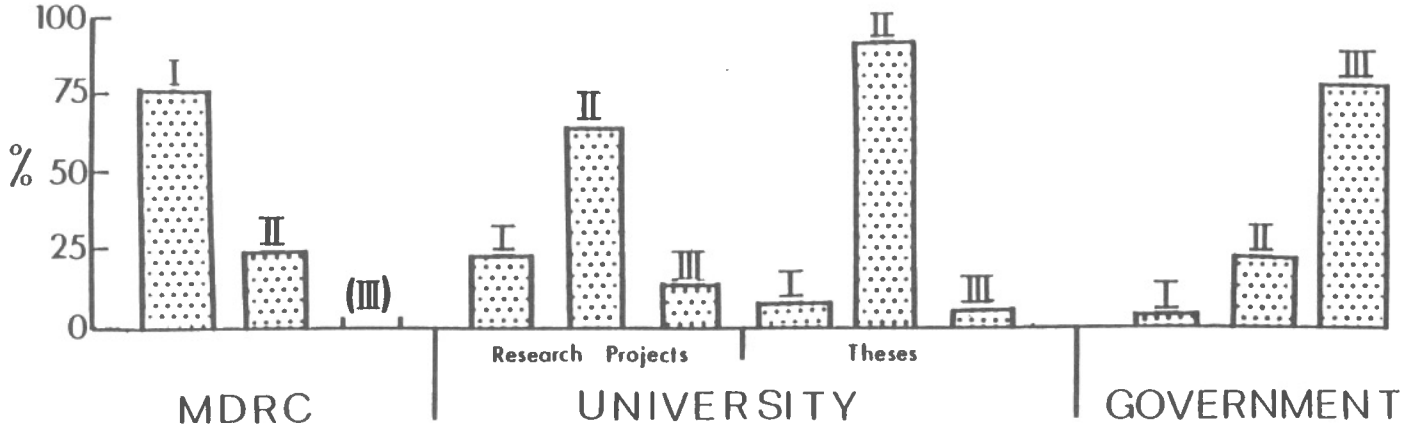


Figure 5.1. Distribution of research projects in University and Government and in proposed Mineral Deposits Research Centre.

techniques that can be applied to specific research problems within integrated projects. Routine samples to be analyzed for routine elements should be contracted out to industry as the task can be handled more efficiently and at a lower cost than in a government laboratory.

The contracting out process as it now exists can be improved. Blanket contracts specifying detection limits for different elements do not allow for the specific needs of a researcher. For example, the current contract in one division for rare earth analyses specifies a 1 PPM detection limit for Eu, but the plotting of chondrite normalized diagrams for research purposes requires a much better detection limit than this. The major user of commercial laboratory services, the mining industry, allows each individual to purchase the services from the laboratory or laboratories he feels is best suited to his needs and budget.

More flexible contracting can be achieved through the Department of Supply and Services contracting system by issuing dollar value blanket contracts rather than element specific dollar contracts to a variety of laboratories. Consultation between the researcher, a GSC laboratory consultant who can advise on methods, and the commercial laboratory can enable the best technique to be selected. Quality control of results can be monitored by the inhouse laboratory through the use of standard reference materials and blind duplicates.

Research and mapping requirements

Certain specific mapping or research requirements can easily be contracted out to consultants, universities or research institutes, whereas others cannot. If the requirements of the project are clearly spelled out tenders could be called. For example park assessment work, rather than tying up the researchers time, could be contracted to consultants.

5.4.5 Publications

In response to the question in the questionnaire "How do you believe the GSC should publish their results?", the highest preference was given, on average, to "Current Research" followed closely by formal GSC publications (Papers, Bulletins and Memoirs), Open File reports, refereed journals, with open house sessions and presentations at national and/or international meetings trailing far behind. There was some difference in the preference given to the different methods of communication, with industry giving top priority to Open File reports and academics and the provinces giving these a distinctly lower priority.

The Advisory Committee sees no necessity for a formal recommendation on publication policy, but stresses that many individuals take much too long to publish their data and interpretations. Within the GSC, individual scientists regard data collected by or for them as their own. It was made very clear from comments appended to our questionnaire that the public outside the GSC regards data collected at public expense as public property and wish to see it placed in the public domain as soon as possible, without interpretation if the individual researcher accumulating it is unable to provide the interpretation in a reasonable time-frame. The Advisory Committee makes no recommendation on this issue; however GSC management should be fully aware of this issue and they should act to see that individual researchers do not abuse their privilege with respect to data.

5.4.6 Mineral Deposits Research Centre as compared with 'In House' research at the GSC

D.F. Sangster has been arguing forcefully for several years that the GSC is not capable of being a first class research centre, due to its managemenent structure and the way in which its priorities are set. At a meeting of mineral deposits research scientists, organized by J.M. Franklin and held at the University of Toronto in 1982, it became clear that whereas a single centre might be able to handle the research requirements, the great size of Canada and the need for reasonable accessibility for scientists from all parts of the country to such a facility, dictated that three such centres would be required to serve the needs of the country.

One of Sangster's key arguments in favour of a centre is that the research always receives a low priority in relation to the line or service functions of scientists at the GSC, because research projects are 'bottom-generated' whereas the service functions are 'top-generated'.

The Committee is in overall agreement with this statement, but not in its use as an argument. In section 5.2.2.1.1 of this report, the Committee has made the recommendation that GSC management acknowledge the equality of the research function with the service function of scientists engaged in mineral deposits research, that it take steps to develop objectives and focus the research of individuals into fewer but multi-faceted projects and that it provide a much stronger monitoring of accountability. If this

major re-orientation of thinking and action is achieved on the part of management, Canada will have gone far towards achieving the Mineral Deposits Research Centre that it needs and a separate centre will become unnecessary.

Sangster envisaged a mineral deposits research centre as focussing on Type I (fundamental) research (Figure 5.1). Reference to Figure 2.1 indicates that once the environment within the GSC for mineral deposits research is improved, this will never move to boxes c-I (fundamental ore deposits research) or d-I (fundamental ancillary studies) but will remain near the centre of the matrix. On the other hand, the Committee concludes that within the Canadian context and the current economic environment this is where it belongs and that much of Type-I research is the responsibility of the universities.

APPENDIX A

CGC Advisory Committee Study of GSC Mineral Deposits Research

TERMS OF REFERENCE

1. To determine and document the current level and types of mineral deposits research in the Geological Survey of Canada.

2. To assess its relevance and adequacy to users in industry, university and government sectors, and for Branch and Departmental national responsibilities mandates.

3. To assess the timeliness, relevance, quality and quantity of publications reporting on the results of mineral deposits research at the Geological Survey.

4. To assess the range, adequacy and quality of research equipment, support staff and analytical services available to support mineral deposits research.

5. To examine the methods and procedures used in originating, implementing, assigning priorities and managing mineral deposits research projects.

6. To identify new initiatives and opportunities for Geological Survey of Canada research.

7. To make written recommendations, as appropriate, to the Director General, Geological Survey of Canada concerning ways in which the quality and effectiveness of mineral deposits research and reporting of results might be improved. The Canadian Geoscience Council Committee shall report its findings and appropriate recommentations in writing to the Director General, Geological Survey of Canada. The report of the Committee shall be made public, but the mechanism and format of publication shall be determined by mutual agreement of the Director General, Geological Survey of Canada and the Chairman of the Canadian Geoscience Council Committee.

8. Unless otherwise agreed to by the Director General, Geological Survey of Canada and the Chairman, Canadian Geoscience Council Committee, the Committee's report shall be submitted to Geological Survey of Canada within one year of the formal commencement of the study.

R.A. Price
Director General
Geological Survey of Canada

February, 1985

APPENDIX B

Activities of the Committee

At its initial meeting, the committee discussed its mandate and agreed that this could only be fulfilled after meetings with all of the individual scientists involved in mineral deposits research **per se** within the GSC, after a briefing on the activities of divisions of the GSC and other departments within EMR that impinged on mineral deposits research, and after receiving as wide an input from all facets of the Earth Science Community as possible.

The first activity of the committee was to design three questionnaires which were sent out in May, 1984 to selected individuals in industry, and in the universities and to each of the Ministers of Mines of the Provinces and to ministers representing the Federal Territories. Return of these were requested by mid-July, at which time the responses were compiled.

The Committee met in Ottawa from 23rd to 30th September, during which time they had interviews lasting from 15 minutes to 1 hour with 38 individuals representing the GSC and other relevant sectors within EMR, including Dr. W.W. Hutchison, Assistant Deputy Minister. They also toured laboratories and devoted one day to receiving briefs from Dr. M. Vallée, SOQUEM, Mr. M. Knuckey, Falconbridge Copper Corp. Ltd., Dr. D. Wahl, Derry, Michener, Booth and Wahl, Dr. R. Smyth, B.C. Department of Mines, Professor D. Strong, Memorial University and Professor B. Nesbitt, University of Alberta, who they had invited to Ottawa especially for this purpose. The Committee then wrote this report before leaving Ottawa.

APPENDIX C

Mineral deposit, metallogenic and related studies at the Geological Survey of Canada 1984

A Brief
Submitted to the Canadian Geoscience Council Advisory
Committee on Mineral Deposits Research
at the Geological Survey of Canada

by

Economic Geology and Mineralogy Division

August 1984

CONTENTS

Tables

INTRODUCTION

This brief has been prepared for the CGC Advisory Committee (hereinafter The Committee) to provide a corporate statement of the status, objectives and operations of Economic Geology and Mineralogy Division of the Geological Survey of Canada; the principal compilers were D.C. Findlay, J.M. Duke, C.R. McLeod and A.G. Plant.

The main intent of this document is to provide factual background information on Economic Geology and Mineralogy (EGM) Division and its predecessor units in the Survey. More subjective comments are, however, also introduced, particularly in Sections 4 (Statement of Views) and 5 (Conclusions). One of the reasons for making a corporate submission to the Committee is to describe the multi-faceted role that a quasi-research unit such as EGM must fill within a line Department in the federal government system. It has been said that the degree of freedom to pursue discipline-oriented research in an organization such as the Geological Survey falls somewhere in the spectrum between that available to researchers in industry (relatively low) and that available to researchers in universities and dedicated research institutions (relatively high). The prime function of a government line department agency is to deliver government programs that provide services to the public and its particular 'client sectors' in the public. Generally, an accepted philosophy is that the effective delivery of useful programs depends on the cumulative acquisition of knowledge about the program subject and this in turn depends in part at least on research, both mission-oriented and curiosity-oriented. A government line department agency is however, continually caught in the squeeze between its obligations and mandates to deliver programs providing services to the public and its need to ensure that such programs are effective through reliance on a cumulative knowledge/research base in the program area. This dichotomy of obligations is by no means unique to government agencies and similar analogies can be drawn in the case of universities (teaching vs research) and industry (corporate economic returns vs research). The end result, however, in the Geological Survey as in many other organizations is that basic, pure or curiosity-oriented research can become increasingly a discretionary function whose base is under continual erosion due to demands for more (politically) urgent non-discretionary work related to program delivery.

It should be clear, however, that the above is not intended as an apology; it is a fact of life in a government line agency. However, in a corporate sense we subscribe strongly to the view that scientists in Economic Geology and Mineralogy Division must retain the flexibility to be actively involved in mineral deposits and metallogenic research if they are to fulfill their program delivery responsibilities in a competent manner, both now and in the future. The dilemma we face is thus one of making the most effective use of limited resources (including researcher's time) to simultaneously maintain both the research and program delivery functions at an acceptable level. Most organizations and individuals face similar dilemmas.

One objective of this Brief is thus to provide the Committee with background information that may allow it to ponder the various ramifications of the key issue outlined above, in the context of its deliberations on the future of mineral deposits research in the Geological Survey.

2. THE GEOLOGICAL SURVEY AND THE FRAMEWORK FOR MINERAL DEPOSITS RESEARCH

The original mandate ('Logan's Mandate') of the Geological Survey of Canada contains the precursors of mineral deposits research. The 'Resolution' in September 1841 of the Legislature of the Province of Canada (formed through the uniting of Upper and Lower Canada in 1840) specified that "a sum not exceeding one thousand five hundred pounds sterling be granted to Her Majesty to defray the probable expense in causing a Geological Survey of the Province to be made".[1] Institutionalized by an Act of Parliament in 1842 and re-enforced again in 1845 ("whereas a Geological Survey of this Province of Canada has been instituted for ascertaining the Mineral Resources thereof...")[2] the Geological Survey under Logan emphasized from its beginnings the assessment of the economic mineral endowment of the "Province" and the collection and curation of mineral specimens representative of this endowment.

Through much of the history of the GSC studies of mineral deposits were conducted both as discrete projects and as work integrated with regional mapping projects. The latter were commonly reported in GSC Memoirs as the familiar 'Economic Geology' chapters (albeit often tacked on at the end, apparently somewhat as an afterthought). Fluctuations over time in the emphasis on economic geology matters were attributable variously to lobbying by industry, federal and provincial political pressures, available funding and the whims or biases of successive administrations.

The Bureau of Economic Geology of the Department of Mines was created in 1934 and lasted about 2½ years; it included little other than the Geological Survey and its function was "to promote and publicize the Survey's assistance to prospecting and mining through its mapping and exploration work...".[3] The appointment of the Survey as the geological arm of the Atomic Energy Control Board of Canada in 1946 represented the beginning of a long but somewhat cyclical emphasis on the geology and inventory of radioactive deposits and occurrences that led to the formation of the Radioactivity Resources Division in 1950, forerunner of the Mineral Deposits Division of 1955. The latter embarked on a program of studying mineral occurrences in Canada on a commodity basis; and the results of these studies have been published in the Economic Geology Series Reports. From 1960 to 1979 the Geology of Mineral Deposits Section (8 geologists and 1 support person in 1960) was bounced around in four different divisions with bedfellows that at various times included practically all GSC units except the Calgary and Bedford components, the geophysicists and the predecessors of the current Geological Information Division (library, cartography, etc.). For example, the 1960-67 Economic Geology Division included Pleistocene, Engineering and Groundwater Geology, and Geochemistry Sections. The Economic Geology Subdivision, created in 1972, was again given full Division status in 1979, but with a strength of about 50, it was one of the smallest of the Survey's nine divisions.

The reappearance of Economic Geology as a full division reflected the increasing emphasis placed on mineral resource matters by the Department (Energy, Mines and Resources), the Sector (Science and Technology; later Earth Sciences) and the Branch (Geological Survey)[4] particularly in the 1970s. This was due to a number of factors but three

---

[1] Blackadar, R.G. 1976. A Short History of the Geological Survey of Canada, Past Achievements and Future Goals; Supply and Services Canada, Cat. No.: M40-38/1976, Ottawa, p2.

[2] Robinson, S.C. 1972. The Geological Survey of Canada – Into the Seventies, the Fourteenth Decade; Geological Survey of Canada Miscellaneous Report 18, Ottawa, p21.

[3] Zaslow, M., 1975. Reading the Rocks: The Story of the Geological Survey of Canada, 1842-1972; MacMillan Company of Canada Limited, Toronto, p379.

[4] This Department, Sector and Branch terminology is typical of Canadian government line agency organizational structure.

important ones were: a) the priorities placed by the federal government on economic sectors in Canadian society; b) the devolution (in practical as opposed to jurisdictional terms) of program delivery responsibilities in certain resource matters from the federal government to the provinces (manifested in part by the General Development Agreements signed with the provinces in 1974); and c) the renewed emphasis by the federal government in the development of 'National' policies in a number of sectoral areas, including minerals and energy. These developments served to focus attention within the Department (Energy, Mines and Resources) on the economic leverages in resource matters. Although the general question of concern over the continuing availability of non-renewable resources (driven by the 'energy crisis' and such developments as the 'Tragedy of the Commons' argument and the Club of Rome "Limits to Growth" study) was dominated in the mid-and-late 1970s by preoccupation with energy, it also spilled over into mineral resource questions. In the 1980s the situation reversed itself, largely as a result of the recession of 1981-83. No longer are concerns about resource availability dominant; rather the preoccupation is with jobs, productivity, survival of industries (minerals included) increasing displacement of Canada's traditional share of global mineral markets by foreign (often state-supported) competition, and the severe social disruptions associated with the collapse of single industry mining communities (e.g. Schefferville).

These developments (fear of resource scarcity in the 1970s and saturation of mineral markets, falling metal prices and declining demand in the 1980s) put increasing pressures on government agencies such as the Geological Survey to contribute to solutions; in the first instance to assess, in quantitative terms the nations's (energy and mineral) resource base; in the second instance to develop new concepts, technologies and programs that could lead to the discovery of new resources in mining camps or districts that were running out of ore, or alternatively that could lead to the exploitation of non-traditional alternative resources in districts and communities where social and economic infrastructures were well established through exploitation of conventional resources.

At the level of operational units such as Economic Geology Division and Resource Geophysics and Geochemistry Division in the Geological Survey, these global developments translated to pressures to increase the scope and applicability of mineral deposits and exploration technology research. Paradoxically, because of the social concerns in government priorities, they also led to the effective dilution of resources and time available for research due to the political necessity to design, implement and administer programs aimed at short-term stimulatory (in an economic and social sense) measures as opposed to longer-term, more fundamental research programs.

3. ECONOMIC GEOLOGY AND MINERALOGY DIVISION

3.1 Mandate and objectives

The modern legal authority for the Geological Survey (and its components) is derived from the Resources and Technical Surveys Act (RSC 1970 and 1978-79). In part, the objectives of EGM are contained within the official Geological Survey objective statement which is:-

"To ensure the availability of comprehensive knowledge, technology and expertise pertaining to the geology of the Canadian landmass and offshore areas, including mineral and energy resources and conditions affecting land and seabed use, as required for effective exploitation of mineral and energy resources, effective use of land, estimation of the resource base of Canada, and formulation of policies."

More specifically, the Economic Geology and Mineralogy Division objectives are officially stated as:

"To ensure the availability of comprehensive geological knowledge, technology and expertise concerning metallic and other mineral deposits, to determine the geological distribution, origin and potential abundance of Canada's mineral resources to facilitate exploration, land-use planning and policy formulation, and to provide compositional analyses of rocks, minerals, ores and other geological materials."

Strategic objectives and priorities for Economic Geology were defined in Departmental Strategic Planning documents (August, 1983) as:

1st priority: "to improve the knowledge base on the nature and occurrence of mineral deposits in Canada and to assess their economic potential"[1]

2nd priority: "to conduct research on how, when, where and why mineral deposits form, in support of mineral exploration".

3.2 Structure, organization and facilities

The present Economic Geology and Mineralogy Division (EGM) was formed as a result of a Branch (GSC) reorganization effective April 1, 1984 (see Fig. 4.2 text). This involved the merging of the Economic Geology Division with the Analytical Chemistry and Mineralogy Sections of the former Central Laboratories and Technical Services Division. These components became the Economic Geology and Mineralogy and Chemistry Subdivisions.

About a year prior to the establishment of EGM, organizational changes had been made in the former Economic Geology Division. The major changes were the introduction of two new sections – Regional Metallogenic Studies (RMS) and Regional Mineral Resources Assessment (RMRA). These changes were accompanied by the recruitment of seven new Research Scientists to fill staff vacancies created by retirements (4), resignations (1) and transfers (2) over the previous two years. An eighth Research Scientist was recruited in 1984 as a result of an additional person year made available to the Division through the new federal-provincial ERDA (Economic and Regional Development Agreement) process which became operational in 1984.

The changes made in Economic Geology Division in 1983 were for three principal reasons: (1) to highlight the importance of regionally-oriented work in mineral deposit studies and metallogeny (Regional Metallogenic Studies section); (2) to formalize Division work in mineral resource assessment including uranium assessments (Regional Mineral Resource Assessment); (3) to provide a better balance in distribution of research and support staff amongst the various sections within the Division.

Of the eight new recruits in the RES (Research Scientist) category, two were assigned to Regional Mineral Resource Assessment (RMRA), three to Regional Metallogenic Studies (RMS), one to Mineral Deposits Geology (MDG), and one to Mathematical Applications in Geology (MAG). The eighth is a Stable Isotope geochemist (administratively also in MDG) who will be assigned half of his time as a GSC (EGM) contribution to the joint GSC-University of Ottawa-Carleton University Stable Isotope Facility located at the University of Ottawa.

Fig. 4.3 shows the current organization structure of EGM. The Division has a total staff of 89 person years, of which 32 are scientific staff, 23 are scientific support, 25 are technical support and 9 are administrative and clerical.

[1] It will be noted that this is little changed from the original GSC 'Logan's Mandate'.

As noted earlier the Division is organized in two subdivisions – Economic Geology (50.5 person years) and Mineralogy and Chemistry (38.5 person years).

3.2.1 Economic Geology Subdivision

This Subdivision contains five formal sections and two smaller work units. Their roles with staff person-years in parentheses are:

3.2.1.1 Mineral Deposits Geology (MDG) Section (10 person years) – Head, J.M. Duke

The major objectives of the Section are to develop and maintain mineral deposits expertise on a national basis and contribute to the success of exploration efforts by the mineral industry. These are accomplished by

(a) acquiring and synthesizing data on Canadian mineral deposit types, other than uranium, so that their common characteristics and critical differences are more fully appreciated, and

(b) developing and improving genetic models for major deposit types, and testing these models by further observation and research.

3.2.1.2 Regional Mineral Resource Assessment (RMRA) Section (8 p.y.) – Head, V. Ruzicka

The Regional Mineral Resource Assessment Section conducts nonrenewable resource assessment studies of specific areas. These include resource appraisals of uranium-bearing areas and deposits and assessments of mineral resource potential for land use planning activities including national parks and other conservation areas. The assessments are based on regional metallogeny as well as on local studies of mineral deposits and their geological environments.

3.2.1.3 Regional Metallogenic Studies (RMS) Section (7 p.y.) – Head, S.M. Roscoe

The Section objective is to carry out areally focussed investigations of the distribution of different types of mineral concentrations in terms of their relationships to geological histories of distinctive domains within major tectonic units throughout Canada. These are required for:

(a) elucidations of the economic significance of features outlined in other geological publications;

(b) selection of desirable foci for geological mapping and other work;

(c) critical tests of alternate genetic hypotheses for the formation of mineral deposits, leading to refinements of conceptual models used in exploration; and

(d) evaluations of mineral resource potential in designated areas.

3.2.1.4 Mathematical Applications in Geology (MAG) Section (5 p.y.) – Head, F.P. Agterberg

The objectives of the Section are:

(a) to develop and apply probabilistic methods of mineral resource estimation for land-use planning purposes;

(b) to provide statistical expertise and services to projects throughout the Geological Survey; and

(c) to develop statistical exploration methods for use by the mineral industry.

These objectives are met by maintaining a long-range program on mathematics and statistics applied to solve geological problems. Geostatistical techniques and systems of computer programs are prepared for use in projects normally carried out in collaboration with other Geological Survey staff. Documented computer programs may be transferred to other sections or to outside organizations.

3.2.1.5 Mineral Resource Information Services (MRIS) (5 p.y.) – Head, D.F. Garson

MRIS has overall responsibility for all commodity and metallogenic files of the Economic Geology Subdivision. It acts as the compiler and curator of the national computer-processable mineral deposits file (CANMINDEX) as well as providing programming services for other Subdivision project files and some library and reference services.

3.2.1.6 Laboratory and Scientific Support Unit (6 p.y.) – Head, R.D. Lancaster

The Subdivision laboratories prepare polished sections and slabs and mineral separations for specialized analyses and maintain a common facility for microscopy, photomicrography and fluid inclusion studies (pending). Support staff are assigned to individual projects, commonly on a long-term, shared basis. One staff member and one on secondment prepare many of the maps, slides and diagrams used to illustrate the Subdivision's oral and published presentations.

3.2.1.7 Special Projects (3 p.y.) – G.A. Gross, D.F. Sangster, L.M. Cumming

Three senior staff geologists report directly to the Subdivision (i.e. Division) management. They have responsibilities that include: the geology of iron and manganese deposits in Canada; the geology of Canadian lead and zinc deposits and related projects; the curation and management of collections of ores and host rocks and coordination of student hiring for the Subdivision. These individuals frequently act as advisors on a variety of Divisional and Branch matters.

3.2.1.8 Administration (6 p.y.) – Director, D.C. Findlay

The Division is managed by the Director. A.G. Plant is Head of the Mineralogy and Chemistry Subdivision but the equivalent position for Economic Geology Subdivision has not been staffed since the April 1984 reorganization and section heads report to the Division Director. The Assistant to the Director, Division Secretary, Administrative Officer and two clerks provide support, the last three dealing chiefly with financial and personnel matters.

3.2.2 Mineralogy and Chemistry Subdivision – A.G. Plant

The Mineralogy and Chemistry Subdivision contains two Sections (Mineralogy and Analytical Chemistry), the former with a staff of 21, the latter with 17. With the exception of the geochemistry laboratories in Resource Geophysics and Geochemistry Division and the geochronology laboratory in Precambrian Geology Division, the Subdivision contains the centralized Ottawa analytical facilities of the Geological Survey. The major objectives of the Subdivision are:

(a) To provide chemical and mineralogical support (data, advice, assistance) as required for Branch scientific projects, and occasionally for other projects and organizations, through the development and operation of chemical and mineralogical laboratories.

(b) To develop and maintain, by means of ongoing research and development on methods and instrumentation, an up-to-date capability to provide the expertise required;

(c) To carry out mineralogical research studies on minerals and on selected mineral deposits, independently or in collaboration with other geoscientists;

(d) To develop and curate National and Branch rock, mineral and meteorite collections;

(e) To provide mineralogical information to the Canadian public.

These objectives are accomplished in the respective sections as follows:

3.2.2.1 Mineralogy (MIN) Section (21 p.y.) – Head, A.G. Plant

The Section provides the facilities and expertise for mineralogical studies by maintaining and developing laboratories for X-ray diffraction and crystallography, electron microprobe analysis and scanning electron microscopy. These are complemented by the sample preparation and mineral separating laboratories, the latter being almost exclusively devoted to the needs of geochronological research. The Section has responsibility for the Reference Collection Facility where it maintains the GSC rock collection, while the Reference Series of the National Mineral Collection (approximately 14 000 specimens) and the National Meteorite Collection are housed at 601 Booth Street. Information to the public is provided through the preparation and sale of sets of rocks and minerals, the free examination of specimens submitted by the public, and the preparation and publication of guidebooks to Canadian mineral areas as an aid to collectors and tourism.

3.2.2.2 Analytical Chemistry (CHEM) Section (17 p.y.) – Head, G.R. Lachance

The various analytical techniques used to provide compositional data for rock, ore and mineral samples range from classical chemical methods for unusual samples to instrumental techniques that include atomic absorption (flame and graphite furnace), infrared analysis, optical emission spectroscopy, and X-ray fluorescence spectrometry with both wavelength and energy dispersive systems. As much as possible, instruments in the various laboratories are programmed to provide a suite of elements automatically with a minimum of operational input. Method development is a necessary prerequisite for the laboratories and is undertaken, often concurrently, with requests for analyses of materials for which the Section does not have established methods. The Section has also taken a leading role in the study and certification of international standard reference materials for chemical analyses.

3.3 Resources

Financial and person year resources for the Geological Survey are shown in Table C.1 for the current and preceding two fiscal years. In terms of dollar and personnel resources, EGM has the fifth largest budget within the Geological Survey.

It is of interest to compare dollar resources for Economic Geology over the past few years, particularly the discretionary (i.e. non-salary) funds available for field operations and research. Table C.2 compares the relevant figures over the five year period 1980/81 to 1984/85. Of interest is column D showing the average funding available per field project over this period. It will be noted that this has increased by only about $500 (current dollars) per project over the five-year period. In constant (1980) dollar terms, average project funding has decreased by 18 per cent between 1980/81 and 1984/85 (Column F). Person-year resources have remained about constant on the Economic Geology side for the last five years.

The Division has been allocated temporary (5-year) additional resources to design, implement and manage a variety of regional mineral deposit and metallogenic projects under the new federal-provincial ERDA (Economic and Regional Development Agreement) mineral development subsidiary agreements. To mid-1984 agreements were in place with the provinces of Newfoundland, Nova Scotia, New Brunswick, Manitoba and Saskatchewan and the resources assigned to EGM for these programs are summarized in Table C.3. The bulk of the expenditures on the ERDA programs will be through contracts with appropriate institutions and individuals.

In addition to the formal ERDAs, EGM staff are involved in the provision of technical expertise and administration of mineral deposit projects in two separate federal initiatives in Quebec:- Gaspé mineral program and the Eastern Townships (Asbestos) program. Some dollar resources (Table C.3) have been transferred to EGM for these proejcts but no additional person-years are provided.

3.4 Project Data

Table C.4 lists current projects within EGM and identifies them by Field, Laboratory, Administration and Office category. It should be noted that the classification of projects is in some cases, somewhat arbitrary, in that many 'laboratory' or 'office' projects commonly also have a small field component (usually collection of materials). Conversely, of course, field projects always carry an analytical/office component. In general, where the objectives of the project depend basically on field-oriented studies of one type or another, the project is classified as 'field':

Table C.4 shows that about half the projects in Economic Geology Subdivision (23 of 40) are categorized as field whereas in Chemistry and Mineralogy Subdivision the majority (5 of 9) are, as might be expected, categorized as laboratory.

Projects are created in a number of ways and for a number of reasons. Certain projects, chiefly in the administrative and office categories are institutional in the sense that they exist for administrative convenience or necessity and serve primarily as a mechanism for the management and control of resources and the expedition of routine administrative services. Certain projects have been created in response to outside demands for work or products that must be provided by the Division, either to other units within EMR or to other government agencies or processes. Project 640402 is an example of the latter. "Certification of bedded and non-bedded mineral deposits" (number 13 of Table C.4) is a service function provided by the Division (through Departmental headquarters) to the Department of Finance on the interpretation (on a case-by-case basis) of definitions concerning mineral deposits in the Income Tax Act. Projects 840003 and 840012 (numbers 21 and 35 of Table C.4) were created, in part, to enable the Division to have a continuing capacity to conduct mineral resource assessments of northern lands, for a number of land-use planning activities of other federal government departments (DIAND, Parks Canada) etc.

For the most part scientific projects were and are designed in response to perceived needs (either internally or externally) for research on particular topics, commodities or deposit types. Many projects have evolved internally as a result of the interests and research paths of individual scientists ('bottom driven'); others have been generated in response to perceived new scientific or strategic needs by the Department or Branch ('top driven'). A recent example in this category is number 16 of Table C.4 ("Metallogeny of Marine Environments, including Active Spreading Ridges").

Table C.1. G.S.C. Resources

	Person Years						Dollar Resources (Personnel, Operating and Capital) – $ 000					
	Utilized				Allocated		Utilized				Allocated	
Subactivity (Division)	1982-83	% of Total	1983-84	% of Total	1984-85	% of Total	1982-83	% of Total	1983-84	% of Total	1984-85	% of Total
Sedimentary & Petroleum Geology	152	19.6	144.5	18.1	151	19.5	8,853	17.5	10,939	19.9	12,651	20
Atlantic Geoscience Centre	104.9	13.5	109.4	13.7	113	14.6	9,580	19	8,958	16.3	14,596	23
Resource Geophysics & Geochemistry	97.4	12.6	97.5	12.2	98	12.6	7,052	14	7,578	13.8	8,181	12.9
Geological Information	95.6	12.3	99.6	12.5	95	12.2	3,717	7.3	4,170	7.6	4,624	7.3
Economic Geology (and Mineralogy, 1984-85)	48.7	6.3	54.4	6.8	89	11.5	2,522	5	2,578	4.7	5,220	8.2
Precambrian Geology	73.5	9.5	74.5	9.3	74	9.5	4,583	9.1	4,141	7.5	5,472	8.6
Terrain Sciences	65.9	8.5	68.4	8.6	64.25	8.3	4,241	8.4	4,511	8.2	4,065	6.4
Cordilleran Geology	46.2	6	50.1	6.3	46	5.9	3,117	6.2	3,406	6.2	3,390	5.4
Central Laboratories & Technical Services	46.4	6	48.6	6.1	-	-	1,855	3.7	2,391	4.3	-	-
Activity Management & Support (Branch HQ)	44.3	5.7	52.3	6.5	45.75	5.9	5,024	9.9	6,306	11.5	5,160	8.1
Totals	774.9		799.3		776.		50,544		54,978		63,359	

The following major items are included in the expenditures and allocations above ($000) for:	1982-83	1983-84	1984-85
Energy Research and Development	3,108	5,335	5,914
Atomic Energy of Canada Limited	986	989	
Nova Scotia Minerals Program	744	1,006	
Newfoundland Minerals Program	1,331	1,478	
Earth Physics-Geothermal Energy R&D	240		
Gaspé-Lower St. Lawrence Program		209	1,026
Bilateral Maritime Boundary Disputes	2,370	626	5,929
Asbestos Strategy			500
	8,779	9,643	13,369

Table C.2. Average Project Field Budgets, 1980-81 to 1984-85

A	B	C	D	E	F
Fiscal Year	Operating Budget for Field Projects	No. of Projects	Average per Project	Annual Inflation Rate %	Average per Project in 1980 $
1980-81	118,600	16	7,400		7,400
1981-82	133,700	17	7,860	11.6	6,948
1982-83	134,600	17	7,920	7.2	6,494
1983-84	128,000	17	7,530	4.1	5,948
1984-85	190,600	24	7,940	4 (Est'd)	6,034

Table C.3. EGM Division Additional Resources for Federal-Provincial Agreements

(Totals for 1984-89)		
Province	Person-Years	$ 000
Manitoba	6.6	787
Saskatchewan	5	500
Newfoundland	15	2 325
Nova Scotia	10	2 170
New Brunswick	5	1 770
Total	41.6	7 552
Average per year	8.32	1 510.4
Federal Initiatives in Québec ($ 000) in 1984-85		
Gaspé Program	-	120
Eastern Townships Program	-	47

In recent years there has been an increasing tendency to construct projects that cut across administration boundaries, both within the Division and (informally) within two or more Divisions. This allows scientists with common research interests to collaborate under a joint project umbrella and encourages a multi-disciplinary approach to problem or process-oriented projects. There is probably general agreement within GSC that this trend will accelerate in the future, and increasingly the project system will move away from the traditional 'one scientist, one project' approach.

EGM is currently experimenting with the evaluation of large umbrella projects or 'super projects' involving a number of scientists in the Division. The prototype for this is number 10 of Table C.4 ("Metallogeny of Ultramafic and Mafic Rocks") which currently involves the part-time efforts of four scientists (Duke, Eckstrand, Scoates, and Hulbert). Other likely candidates for super project development in the future are precious metals and sedimentary copper environments.

Projects are managed, ultimately, by the designated Project Leader, although in practice there is an increasing tendency for joint or consensus management and administration in projects involving groups of scientists, and are subject to the GSC project management system. This has three principal phases within a project year: (1) budgetting and resource allocations by Division (in recent years because of fiscal restraint this component has had little flexibility, with resources allocated to projects essentially on the basis of historical tracks, adjusted according to the particular field component for the budget year); (2) project annual instructions in which the work planned for the current year is set out; (3) project progress reports. The main report is in April, at the end of the fiscal year; a 6-month progress report is also made at the end of September. The formal written reporting cycle is accompanied by a project review procedure which varies from Division to Division. In EGM this usually takes place in November/December and consists of a series of meetings on a section-by-section basis in which project progress, problems etc. are discussed with Division Management. This process is linked to the Branch (GSC) Program Review (November to January) in which Divisions present program/project progress to the Chief Geologist.

3.5 Source events

A number of events have taken place, within both GSC and the Department and externally to the Department in recent years that have or will influence the conduct of mineral deposit research and related work at the GSC in the future. Following are brief notes concerning some of these. The list given is by no means exhaustive and no attempt is made here to provide details of these elements.

3.5.1 GSC Futures Conference

In December 1981 about 60 GSC staff and a dozen invited participants from other EMR agencies participated in a three-day Workshop at Gananoque, Ontario to attempt to identify and discuss some of the main scientific trends perceived to be important for GSC over the next ten years. A significant component of the agenda revolved around the question of client needs. In the context of this note, mineral deposits research and mineral resource assessment were identified as two critical areas of GSC focus. The proceedings of the Conference were recorded in an internal document compiled by D.C. Findlay.

3.5.2 EMR A-Base Review

As part of a government-wide review of existing programs and resource allocations/utilization, the EMR A-Base[1] Review team examined the operations of GSC in 1982. As a whole, GSC received a favourable report. Of the 10 formal recommendations made by the Review team, one pertained to Economic Geology. This concerned the Uranium Resources Evaluation process and a recommendation was made that some person years were surplus to the process and should be transferred from GSC to the Associate Deputy Minister's reserve (EMR) for reassignment at his discretion. It also recommended that the Director General, GSC "develop a plan for resource evaluation" to include other minerals in addition to uranium. In the latter context GSC made representation that the excess personnel were needed to help fulfill obligations to nothern mineral resource assessment projects, required by DIAND and Parks Canada but this representation was not successful. Ultimately, the A-Base Review recommendations were a factor in the reorganization of Economic Geology Division in 1983 to incorporate the former Uranium Resource Evaluation section in the new Regional Mineral Resource Assessment section.

3.5.3 Proposal for a Mineral Deposits Research Institute and subsequent events

In 1980 and 1981 D.F. Sangster of this Division proposed, in a series of articles in Gangue (the newsletter of Mineral Deposits Division, Geological Association of Canada) that basic mineral deposits research was inadequate in Canada and that an independent research institute was needed. Sangster followed this later with a proposal for a "Mineral Deposits Research Centre" which was eventually submitted to the Canadian Geoscience Council. In November, 1981, CGC convened a workshop (organized by J.M. Franklin, EGM) at the University of Toronto to discuss the general question of mineral deposits research in Canada and the specific question of Sangster's proposal. The proceedings of the Workshop were recorded in a report by Franklin to CGC entitled "Future Directions of Mineral Deposits Research in Canada" (CGC Paper 1983-1). Ultimately, this led to the formation by CGC of the McEachern Committee to investigate "Research and Development in Mineral Exploration in Canada". This Committee has not yet reported to CGC.

4 STATEMENT OF VIEWS ON MINERAL DEPOSITS RESEARCH

4.1 Main tracks

EGM takes as a starting position that to retain credibility in the eyes of its clients, both within and outside government it must seek all possible ways to continue and enhance its role in mineral deposits and related research. By the nature of its being a government agency such research will be biased towards the applied end of the spectrum but this must rest on a solid foundation of fundamental research on ore forming environments and processes.

As pointed out in the Introduction to this brief, there are necessary limitations to the degrees of freedom to pursue fundamental research due to the requirements of program delivery. A few years ago an internal time distribution survey made in Economic Geology (then a Subdivision and much smaller than the present organization) concluded that, in the aggregate, about one half of a Research Scientist's working time was actually spent on those activities that could be categorized as research. The balance was spent on a

[1] A-Base: Resources appropriated to carry out the regular ongoing activities of an organization.

Table C.4. Economic Geology and Mineralogy Division project summary 1984-85

ECONOMIC GEOLOGY SUBDIVISION

Serial	Project Number	Project Leader	Section	Title	Field	Lab	Admin	Office
01	690038	Agterberg	MAG	Probability models for estimating mineral potential & geoprocessing				X
02	760060	Agterberg	MAG	Mineral & energy resource evaluation: Probabilistic Methods				X
03	750069	Bell	RMRA	Geology of Uranium Resources of Canada-3	X			
04	840059	Birkett	RMS	Metallogeny of Eastern Canada-II	X			
05	830038	Bonham-Carter	MAG	Geomathematical applications in the intergration of geoscience map data	X			
06	750094	Chung	MAG	Development of computer-based statistical techniques applicable to regional geological and mineral deposit data				X
07	740098	Dawson	RMS	Metallogeny of the northern Canadian Cordillera	X			
08	760014	Dunsmore	MDG	Geology of Uranium Resources of Canada-4	X			
09	820052	Dunsmore	MDG	Metallogenic processes in sedimentary diagenetic environments		X		
10	840050	Eckstrand et al.	MDG	Metallogeny of ultramatic and mafic rocks	X			
11	303109	Findlay	ADMIN	Division Management			X	
12	303121	Findlay	ADMIN	Contracts for Outside Analytical Services			X	
13	640402	Findlay	ADMIN	Certification of bedded and non-bedded mineral deposits				X
14	750110	Findlay	ADMIN	Federal-Provincial and Federal-Territorial Mineral Evaluation Liaison and Coordination				X
15	750098	Franklin	RMS	Metallogeny of the southwestern part of the Canadian Shield	X			
16	820051	Franklin	RMS	Metallogeny of marine environments, including active spreading ridges	X			
17	770024	Gandhi	RMRA	Geology of Uranium Resources of Canada-5	X			
18	680114	Garson	MRIS	Development & Supervision of mineral deposits data bank				X
19	760064	Gross	SP/PR	Geology of mineral resources in the Oceans				X
20	570029	Gross	SP/Pr	Geology and Evaluation of Iron and Manganese Resources	X			
21	840003	Jefferson	RMRA	Regional mineral resource assessment, northern Canada-II	X			
22	700059	Kirkham	MDG	Geology of copper and molybdenum deposits in Canada-I	X			
23	770063	Lydon	MDG	Geology of lead and zinc resources of Canada-II	X			
24	303110	McLeod	ADMIN	Laboratory and Scientific Support Administration			X	
25	810024	Miller	RMS	Metallogeny of the Baker Lake-Thelon region, N.W.T.	X			
26	800023	Poole	Sp/Pr	Special assignments on eastern & northern Canada				X
27	840018	Poulsen	RMS	Comparative Regional Metallogeny	X			

Serial	Project Number	Project Leader	Section	Title	Field	Lab	Admin	Office
28	840051	Renz	MAG	Geological Evaluation & Remote Sensing (GEARS)	X			
29	N.P.	Robert	RMS	Metallogeny of Eastern Canada-I	X			
30	770055	Roscoe	RMS	Metallogeny of the northwestern part of the Canadian Shield	X			
31	750010	Ruzicka	RMRA	Geology of uranium in Canada	X			
32	650056	Sangster	Sp/Pr	Geology of lead & zinc deposits in Canada	X			
33	730042	Sangster	Sp/Pr	A study of certain accessory elements in Canadian sulphide assemblages & minerals				X
34	800021	Sangster	SP/Pr	Lead & zinc in carbonate rocks – joint research with Esso Minerals Canada				X
35	840012	Scoates	RMRA	Regional Mineral Resource Assessment – northern Canada-I	X			
36	770071	Sinclair	MDG	Geology of copper & molybdenum resources of Canada-II	X			
37	N.P.	Taylor	MDG	Stable Isotope Analyses & Research Applications		X		
38	810025	Thorpe	MDG	Organization & preparation of mineral resources component of Economic Geology Report No. 1 – 6th edition				X
39	680060	Thorpe	MDG	Geology of silver & gold deposits in Canada	X			
40	780032	Thorpe	MDG	Lead isotopic studies on genesis of ore deposits				X
Subdivision Totals					23	2	3	12
MINERALOGY AND CHEMISTRY SUBDIVISION								
01	770054	Delabio	MIN	Sample preparation & mineral separating services		X		
02	680023	Harris	MIN	X-ray diffraction analysis & mineralogical studies		X		
03	550101	Herd	MIN	Reference collection of minerals, rocks, ores & meteorites				X
04	380077	Lachance	CHEM	Analysis of rocks & minerals		X		
05	690090	Lachance	CHEM	Development of methods & special special analysis of geological materials		X		
06	400006	Larose	MIN	Preparation of collections of Canadian rocks & minerals for distribution to the public	X			
07	620308	Plant	MIN	Electron beam microanalysis		X		
08	303015	Plant	MIN/ CHEM	Scientific direction of Section program			X	
09	640048	Stenson	MIN	Study of mineral collecting areas of interest to collections & tourists	X			
Subdivision Totals					2	5	1	1
DIVISION TOTALS					25	7	4	13

ADMIN = Administration;
CHEM = Analytical Chemistry;
MAG = Mathematical Applications in Geology;
MDG = Mineral Deposit Geology;
MIN = Mineralogical Studies;

SECTIONS:
MRIS = Mineral Resources Information Services;
RMRA = Regional Mineral Resources Assessment;
RMS = Regional Metallogenic Studies;
Sp/Pr = Special Projects

variety of duties that could be loosely categorized under two headings – 'Administration' and 'Assigned Productivity'. In essence, these two categories covered the program delivery aspects of the operations. There is no reason to conclude that the research component has increased in the intervening years and there is some feeling (although not documented) that it has probably decreased. The reasons are again those set out in the beginning of this brief; they range from providing advice and written input to Departmental policy documents relating to resource management through to the conduct of resource assessments of proposed northern Canada national parks. As noted earlier a recent significant new load on the program delivery side has come about through the introduction of the new federal-provincial ERDA process which requires – in contrast to the former DREE (Department of Regional and Economic Development) federal provincial mineral agreements – the delivery of federal program components in the provinces by federal agencies, including GSC. Since the provinces wish significant mineral deposits and metallogenic components in the new federal-provincial agreements a considerable new responsibility for program delivery will evolve on EGM (refer to Table C.3).

Notwithstanding the above it is considered that there are apparent new opportunities for enhanced mineral deposits research. Some will come about through participation in the ERDA process where GSC A-base projects can be augmented by work conducted under ERDA programs through contracts with universities and individual researchers and through sponsorship of these projects. Other new avenues are arising through the Department's participation in the Boundary Disputes program with the attendant opportunities (and resources) to conduct research on hydrothermal seafloor sulphide sites and processes and for comparisons with ancient environments. Additional new opportunities will arise through a variety of cooperative projects, some of them scientific 'mega projects' such as Lithoprobe and ODP (Ocean Drilling Project).

EGM views scientist's participation in international cooperative projects, both 'scientific' (IGCP, IUGS, Decade of North American Geology etc.) and 'agency generated' (UN, CIDA, scientific exchanges with other countries etc.) as prime opportunities to allow staff to broaden research horizons, both in an intellectual and geographic sense. Such opportunities are, of course, conditioned by the usual constraints regarding domestic workload priorities and funding. Nevertheless, ways and means can generally be found to allow scientists to participate in many such offshore projects. A recent productive example is the investigation by J.W. Lydon of Cyprus base metal deposits and ore fluid alteration effects under the auspices of the International Crustal Research Drilling Project. The scientific findings of this project will be applied in the forthcoming "Metallogeny of Newfoundland Ophiolites" project under the Newfoundland ERDA.

Internally EGM views main tracks for mineral deposit, metallogenic and related work in the future as falling in the following five general categories:

(a) the mineral deposits information base

(b) mineral deposits modelling

(c) regional metallogenic synthesis

(d) mathematical and geostatistical method development and applications

(e) analytical methods development and evaluation.

These five tracks encompass much of the traditional work in mineral deposits (economic geology) at GSC and they can be tied directly to the activity and subactivity objectives and operations set out in sections 3.1 and 3.2 in this brief. As well, however, they are seen to offer the flexibility for a general shift in emphasis of the work of the Division from observation and documentation toward interpretation, quantitative modelling and concept development and testing. Briefly, the elements of the tracks are seen to be as follows.

4.1.1 Mineral deposits information base

This is the traditional and continuing documentation of the nature, distribution and potential abundance of Canada's mineral resources. Historically the approach in this work has been commodity-oriented (national commodity portfolios). Increasingly we see this moving toward a deposit-type orientation. This function includes other aspects of the mineral deposits documentation process, such as for example, the computer-based mineral deposit file systems (CANMINDEX, etc.).

4.1.2 Mineral deposits modelling

The mineral deposits information base underlies the mineral deposits modelling work. We include here a spectrum of activities that range from the construction of descriptive deposit-type models and classifications (currently in progress) through the derivation of quantitative models (e.g. grade/tonnage models) to the investigation of thermal and chemical processes in ore formation. These activities also embrace techniques such as computer simulation and modelling, fluid inclusion studies and stable isotope applications. In the latter context, GSC (EGM) participation in the Joint Stable Isotope Facility (carbon, oxygen and sulphur) with the University of Ottawa and Carleton University will, it is anticipated, form the basis for later establishment of a GSC stable isotope (oxygen, hydrogen) facility at 601 Booth Street.

4.1.3 Regional metallogenic synthesis

This encompasses the regionally-oriented research and applications of the work of the Division. It includes obvious elements of 4.1.1 and 4.1.2 viewed from a regional perspective, primarily to facilitate response to Branch and Departmental priorities in regional program delivery and in the development and maintenance of a regionally-tied expertise base in mineral resource matters. In the northern territories EGM is currently developing a long-term (10 year) plan outlining the priorities for work on a metallogenic domain basis. This work includes the conduct of specific resource assessment projects for land use planning activities by other agencies (e.g. DIAND). In the provinces, much of the ERDA work by the Division will be coordinated through RMS.

4.1.4 Mathematical and geostatistical methods development and applications

Although not strictly tied to mineral deposits research *per se* these methods have obvious applications in mineral deposits research. The treatment and manipulation of numerical data sets, image analysis techniques, statistical modelling (e.g. grade tonnage models), development of logic models, and multivariate analysis methods in regional resource appraisal are all relevant components.

4.1.5 Analytical methods development and evaluation

This track of EGM research falls within the Mineralogy and Chemistry Subdivision. Although much of the effort of the laboratories is devoted to providing routine analytical services to GSC scientific projects, a significant component is directed at the development of new analytical techniques and the application of new analytical technologies

(SEM-Image Analysis, ICP etc.) to the particular research needs of GSC in a variety of disciplines, including mineral deposits research.

4.2 Client needs

EGM, like most government agencies must attempt to serve three general client populations:

(a) government

(b) private-sector interest community (in general, the Canadian mineral industry)

(c) general public.

Not uncommonly, the needs of these client groups may be in conflict or apparent conflict. However, EGM sees its responsibility to client needs as falling into two broad categories.

(a) the provision of an expertise base for the development of federal government resource management and land use policies and programs

(b) the provision of information and concepts for use by the Canadian mineral sector in exploration.

Within these two broad categories there is obviously much scope for a variety of products and outputs. We find also that there are commonly fragmented views amongst clients as to what the principal products from EGM should be. These may range, for example, from "better and more maps" to advanced concepts in mineral deposit models as guides to exploration. In this context, a valuable service that the Committee could provide would be guidance on the mineral deposits research community's perceptions of useful and useable products of GSC research. There is also, it appears, a need for the development of some continuing feedback mechanism to act as a vehicle for transmitting client's views on mineral deposit research products back to GSC management.

5 CONCLUSIONS

It is probably not appropriate to draw conclusions about EGM in a brief prepared by EGM. The Committee will rightly feel that it is its (collective) responsibility to arrive at conclusions. Nevertheless it may be appropriate to offer here some skeletal capsule comment on what may be taken as the current EGM philosophy of operations life. The Committee will, it goes without saying, have its own views on the matter. In brief, the following are the guidelines on which the comments presented in the previous section (views on Mineral Deposits Research) are predicated.

(1) We endorse the concept that, as a part of government agency, our prime responsibility is to provide objective, non-biased, expert-based information and advice on mineral resource matters to the federal government (and by due democratic process, thus to Canadian society as a whole) and to function as an agency of program delivery for the federal government.

(2) We define the role as outlined in 1 above as including, as a prime requisite, the conduct of mineral deposits and metallogenic research and the provision of results thereof, by appropriate publication and information transfer mechanisms to the public in general and to the Canadian mineral exploration industry and the mineral deposits research community in particular.

(3) We believe, in order to fulfill the roles outlined in 1 and 2 above effectively, that we need to strive to enhance our capacity to conduct active mineral deposits and metallogenic research by making the best use of the resources and talents available to us, both internally and through outside contract and collaborative mechanisms. In so doing we recognize the inevitable constraints placed on our efforts through the mix of discretionary and non-discretionary functions we must perform and the currently-accepted philosophy that the trust of federal research responsibilities is 'mission oriented' (i.e. in support of the Department's mandates and strategic and operational objectives).

(4) We fully appreciate that we are far from perfect and cannot be all things to all persons (clients) and we strongly endorse the idea that an examination of our operations by a Committee of outside experts is a healthy and desirable ventilation process. We look forward to the results of the Committee's deliberations.

APPENDIX D

Summary of Responses to Questionnaires

1. Industry responses

   Seventy questionnaires were sent out to individuals representative of themselves or an organisation; 36 responded. Of those responding, 21% were self employed and 79% represented an organization. Of those in an organisation, the average numbers of geoscientists employed was 15. 80% of the respondents were interested in the Cordillera, 92% in the Precambrian Shield, 47% in the Appalachians and 61% in the Maritimes.

   The use made of GSC data was as follows:

< once per week	once per week to once every 2 mos	> every 2 mos
19%	54%	26%

2. Forty two responses were sent out to academics and 30 were returned. Of those responding 40% gave NSERC as their primary funding agency and 20% gave it as their second most important source. Other important sources of funds were EMR grants and contracts, Provincial survey grants & contracts and Industry grants.

3. Questionnaires were directed to the Ministers of Mines of each of the Provinces and Territories.

   Responses were received from Alberta (Energy and Natural Resources Scientific and Engineering Services Research Division), British Columbia, Manitoba, Nova Scotia, NWT Yellowknife, Ontario, PEI, Quebec and Yukon Territory.

Question	Industry Percentage of responses indicating priority				Academics Percentage of responses indicating priority				Mines Ministers Number of responses indicating a priority of*			
	1	2	3	No	1	2	3	No	1	2	3	No
Do you believe that Mineral Deposits Research in the GSC should aim at:												
a) Field mapping related to Mineral Camps	10%	8%	11%	17%	33%	10%	3%	7%		1		5
b) Compilation of data related to specific Mineral Commodities	6	14	19	11	3	10	20	7		2		
c) Compilation of data related to Mineral Camps	14	14	8	17	7	20	17	7			1	4
d) Compilation of data related to Broad-Scale Metallogeny	8	11	8	3	13	13	17	10	2	1	3	
e) Obtaining, a data base on which to advise government on matters of policy making	11	6	8	8	13	7	3	3	3	1	1	
f) Specific research on Mineral deposits of camps leading to genetic conclusions	3	11	11	8	0	20	10	3	2	2	2	1
g) Research as listed under d) but with the aim of increasing criteria on which to base exploration	19	11	17	3	7	3	7	7	3			
h) Research more empirical than e) leading to new exploration methods	0	8	3	8	0	0	3	23			2	
i) Running surveys on a large scale	0	8	8	25	0	0	3	27		1		2

* 1 Provinces and 2 Territories responding

Question	Industry	Academics	Mines Ministers
Should Mineral Deposits research concentrate more on those deposits in which Canada is:			
i) enriched	95%	Not asked	Not asked
ii) lacking	5%		
What should the proportion of (i) to (ii) be?	75:25		

Question	Industry Yes	Industry No	Academics	Mines Ministers
a) Should work be done on a commodity/element basis.	45%	55%	Not asked	Not asked
b) Should there be more geographic metallogenic studies	64%	36%		
c) Should there be more site-specific mineral deposit studies	77%	23%		
d) Does off-shore non-fuel mineral research receive sufficient attention.	63%	36%		

Question	Industry Priority Given	Academics	Mines Ministers
How do you believe the GSC should publish their results?			
a) Current research	2	2	1
b) Open file reports	1	4	3
c) GSC papers, bulletins, memoirs etc.	4	1	2
d) Refereed Journals	3	3	4
e) Presentations at National and/or International Meetings	6	6	6
f) Open House (Show & Tell Sessions)	5	5	5

Question	Industry Yes	Industry No	Academics Yes	Academics No	Mines Ministers Yes	Mines Ministers No
Would you like to develop closer contacts with GSC personnel undertaking Mineral Deposits Research.	83%	17%	93%	7%	90%	10%
If yes, would you:						
a) Welcome GSC scientists to work with your staff for 3 to 12 month periods.	67%	8%*	80%	20%	90%	10%
b) Would you welcome the opportunity to visit and have your staff visit the GSC for similar periods to undertake collaborative studies						
i) with EMR paying their local expenses	44%	8%*	60%	40%	50%	50%
ii) paying local expenses yourself	50%	28%*	50%	50%		
c) Would you welcome, in certain cases, GSC scientists as a co-supervisor of your students	not asked		83%	17%	not asked	
d) Would you welcome the opportunity for some of your students to work at GSC for 3-12 month periods supported by a EMR studentship.	not asked		90%	10%	not asked	

* Not all respondents answered these questions in a way that could be tabulated.

Question	Industry		Academics		Mines Ministers	
	Yes	No	Yes	No	Yes	No
Do you believe that the GSC might have a role to play in locating scientists at certain key deposits during the development stage to thoroughly document the deposit	73%*	27%	77%	23%	33%	67%
If yes, do you believe this activity would be						
a) very important	52%		50%			
b) quite important	48%		45%		100%	
c) only done if nothing better to do	0%		5%			

* Many industry geologists pointed out that this work should continue into the early stages of mining.

PART II

Commentary on the Report of the Canadian Geoscience Council Advisory Committee on Mineral Deposits Research at the Geological Survey of Canada [1]

INTRODUCTION

The Report of the Canadian Geoscience Council Advisory Committee on Mineral Deposits Research at the Geological Survey of Canada (Part I) , forms part of the formal program evaluation process of the Department of Energy, Mines and Resources. It was commissioned by the Director General of the Geological Survey, both to meet the departmental requirements for program evaluation, and to help the Branch meet its responsibilities as a research organization serving 'clients' in the mineral resources industry, the Department of Energy, Mines and Resources, other federal and provincial government agencies, and the geoscience research community in the universities and elsewhere.

This outside peer review of the GSC's mineral deposits research services was particularly timely because of a number of recent developments relating to mineral deposits research in the GSC and elsewhere. There is an increasing emphasis on the use of mineral deposit modelling for the elucidation of the genesis of mineral deposits and for the development of better mineral exploration strategies. Exciting new research horizons are becoming apparent through investigations of seafloor hydrothermal sulphide-forming processes at various places, including the recent discovery sites on the Juan de Fuca and Explorer ridge areas off Canada's west coast. There is a growing concern about the application of the best results of mineral deposits research to the development of resource appraisal techniques for a variety of land use planning purposes, and expanding interest in the application of mineral deposit research activities to the task of promoting regional economic development in various parts of Canada.

Another factor that made this study particularly timely was that on April 1, 1984 the Geological Survey underwent an internal reorganization that was designed in part to sharpen the focus of its efforts in the general area of mineral deposits research. This reorganization resulted in the former Economic Geology Division and the Mineralogical and Analytical Chemistry Sections of the former Central Laboratories and Technical Services Division being combined to form the present, larger, Economic Geology and Mineralogy Division (EGM). This provided a special opportunity to have an outside peer review of the operations of the new enlarged Division, which contains much of the Survey's mineral deposits research component. However, many elements of the GSC's mineral deposit research activities remain in other GSC divisions, notably the Resource Geophysics and Geochemistry Division and Terrain Sciences Division, as well as in other EMR agencies such as CANMET. Accordingly, the Terms of Reference of the Advisory Committee were to study the mineral deposits research activities and products throughout the GSC, to assess their relevance and adequacy, and to identify ways in which the quality and effectiveness of mineral deposits research and reporting of results might be improved, and the Branch might better serve its various clients.

The Advisory Committee, in its report, has commented on most aspects of mineral-related research in the Branch. It has presented 15 major conclusions and has derived from these 26 specific recommendations for GSC management. In the commentary that follows, reference is made to individual recommendations of the Committee as appropriate, but the main intent is to provide a narrative statement that discusses most of the general comments and conclusions provided by the Advisory Committee. It will be useful, as a framework for the discussions to follow, for the reader to refer first to Appendix C of the Advisory Committee's report. This attachment provides the administrative and organizational outline of mineral deposits work at the Survey, both in an historical and current sense.

The Geological Survey wishes to record its appreciation to the Chairman and members of the Advisory Committee for the energetic and prompt manner in which the Committee conducted its investigation and produced its report. The Committee deserves the thanks both of the Geological Survey and of the mineral deposits research community at large for its willingness to take on this difficult task and for the many useful and timely comments and observations to be found in its report.

THE PROBLEM OF THE RESEARCH ROLE VERSUS THE SERVICE ROLE

A difficulty the Committee found in dealing with its topic is that the mineral deposits research function within the Geological Survey is intimately interwoven with the broader responsibilities that the Survey must discharge as an operational agency of a line department (Energy, Mines and Resources). As a part of the Earth Sciences Sector of the Department, GSC is charged broadly with the acquisition and dissemination of geoscience information about Canada's landmass and offshore territory. This includes information on mineral and fuel resources. Obviously, much of this knowledge base rests on the cumulative results of research, but the research component is not always easily or clearly distinguishable from the information acquisition and processing part of its mandate. This non-research function is commonly referred to as the 'line' or 'service' function. In its report, the Committee clearly recognizes this dichotomy and identifies many of the activities in EGM and other GSC Divisions as 'service' functions. However, many of the Committee's conclusions and recommendations, although relevant and perhaps accurate when dealing with the research function in the strictest sense, contain difficulties in application because of the non-discretionary service function obligations. Examples of this problem can be found in the sections of the report dealing with "Commodity Specialists" (4.3.2.14) and "Regional Metallogeny" (4.3.2.15). The Committee concluded, for example, that "The 'commodity' approach to research has not been overly successful within EGM" (Conclusion 4.3.2.14.1) and that "scientists who still function with a 'commodity' approach to their research should be re-assigned to other projects" (Recommendation R4.3.2.14.1). Further the Committee noted that it had "mixed views on whether the type of work performed in the past (in Regional Metallogeny) was more of a research or service function".

Both these subjects illustrate well the problem of attempting to divorce 'research' from 'service' within an operational mandate such as the Survey has. The 'commodity approach' was, historically, a natural and logical organization of manpower in a manner suited to responding to demands placed on the Survey for knowledge of the nature and

[1] Prepared by the Geological Survey of Canada, February, 1985. The amalgamation of the Earth Physics Branch and the Geological Survey of Canada which took effect 1 April, 1986 significantly changed the organizational structure given in Part I, Appendix C by bringing exploration geochemistry, exploration geophysics and economic geology activities together in one administrative unit.

distribution of Canada's mineral resources. This approach perhaps reached its zenith in the late 1960s and early 1970s with the organization of specialists in groups (not only within the Survey but within the Department as a whole) focussing on a single commodity – uranium. This was due almost entirely to a response to policy and strategic priorities of the governments of the times and had little to do with research priorities. Although the commodity approach may not have been "overly successful" from a research point of view, as the Committee has noted, it can be said to have been a generally productive approach from a 'service' standpoint.

This orientation has changed and continues to change within the Survey. Increasingly, the orientation of work has been shifting from a commodity approach to a deposit-type approach. This ranges from formal projects involving a number of scientists working on a common theme (e.g. "Metallogeny of mafic and ultramafic rocks") to less formal groupings of project scientists across administrative boundaries (e.g. "Gold Working Group"). It is anticipated that this process of shifting away from "one scientist-one commodity" will continue.

The case of "Regional Metallogeny" is somewhat different. In mineral deposits, as in many other disciplines, GSC must maintain a "regional expertise" network, to serve as a focal point for response to geoscientific and resource-based economic demands that are regionally oriented. A current case in point is the need for GSC to conduct a variety of mineral deposit and metallogenic projects within the framework of the various federal-provincial mineral development agreements with the provinces. Apart from this, which may be considered in part a 'service' requirement, metallogenic synthesis of the various geological regions of the country is viewed as a legitimate research activity in itself, comprising the integration of cumulative research on mineral deposit types with knowledge of tectonostratigraphic domains to identify, amongst other things, likely favourable target areas for mineral exploration. Within EGM, the regional metallogenic component is new (1983) and longer term plans and priorities for regional metallogenic work are still being evolved.

THE PLANNING, MANAGEMENT AND EVALUATION OF (MINERAL DEPOSITS) RESEARCH

The Committee has noted that "the lack of a system for defining the objectives of mineral deposits research and for evaluating research effectiveness is the single most serious problem with respect to mineral deposits research within the GSC" (Conclusion C5.1.1). A number of the report's conclusions and recommendations bear on this general question (e.g. R5.2.2.1.2 - "that (GSC) management institute a planned approach to mineral deposits research, following plans set by an internal advisory group and that individuals be required to work within the outline of this plan, achieving and publishing results within a pre-set time frame"; see also R5.1.2.2.1- National Advisory Committee on Mineral Deposits Research; etc).

There is little doubt that this is an important topic and one which GSC strives to address conscientiously. There is however, no unique solution. Like every large organization, GSC has internal systems for reviewing and monitoring its operations and the performance of its staff. Doubtless the existing systems are far from perfect. It can be pointed out however, that a not inconsiderable collective time of the agency is spent on these processes during the course of a year (see Appendix C of the Committee Report for a statement of the project review process). Certain elements of program planning are beyond the authority of local units such as Divisions. Certain elements of staff performance appraisal are similarly dictated by Departmental and Public Service Commission mechanisms outside of local units. Nevertheless, a considerable amount of local autonomy in matters of setting, monitoring, and evaluating research objectives, progress and effectiveness is vested at Division level and is a Division responsibility. Within EGM certain research patterns (e.g. commodity-based approach) have long been established by historical tracks, as discussed above. It has been noted that many such historical tracks are in the process of being changed and others will be changed in the future.

A number of ad hoc internal advisory committees already exist within EGM to deal with a variety of research-related matters. To date, these have not been formalized to a permanent internal research advisory committee (Committee recommendations R5.1.2.1.1 and R5.2.2.1.2) but GSC views this recommendation as an important one and steps will be taken to put such a mechanism in place.

The proposal for a larger, external "National Advisory Committee on Mineral Deposits Research" (Committee recommendation R5.1.2.2.1) raises the question of relationships between mineral deposits research inside and outside the Branch. The nature and title of the proposed committee suggests that it could or should have a much broader mandate than merely advising on mineral deposits research within the Geological Survey. It is supposed that mineral deposits research within the universities, within provincial agencies and within industry would also be appropriate targets for such a Committee. In view of the current parallel CGC investigation of Research and Development in Mineral Exploration in Canada (McEachearn Committee) it would seem useful to defer action on this until that Committee has reported.

Two other points noted by the Committee are relevant to this topic as well as to the preceding discussion of "Research versus Service". The Committee concluded (Conclusion C4.2.2) that "research topics, in large part, are generated from the bottom up" and that (Conclusion C4.3.1.1) "...there is a perception amongst many scientists (but disputed by management) that service always takes precedence over research." These are related to recommendations R5.2.2.1.1 ("that GSC management go on record as recognizing that performance in the research function is equally important to that in the service function for the advancement of an individual's career and to achieving the goals of GSC") and R5.2.2.1.2 ("that management institute a planned approach to mineral deposits research...").

Branch management endorses these recommendations but not the conclusions. As in many organizations, a considerable proportion of a manager's time is spent in attempting to ensure a reasonable balance between time available by staff for research and time alloted to the legitimate requirements of service functions. As for recommendation R5.2.2.1.1, this is entirely consistent with present practice in GSC where the research scientist appraisal process is predicated on assessment of scientific staff on the basis of performance as a scientist.

EGM LABORATORIES

A part of the Advisory Committee's mandate was the examination of the newly-acquired (through merger with the former Central Laboratories and Technical Services Division) mineralogical and chemical laboratories, and a number of conclusions and recommendations in the report relate to the operation of the laboratories. In considering the laboratories, the Committee recognized that their function is to serve the Geological Survey as a whole and not just EGM. For the most part the Committee found that the mineralogical laboratories are state-of-the-art in terms of technology and expertise.

The chemical laboratories on the other hand, come in for considerable criticism. GSC has been aware of deterioration in technology in the chemical laboratories for some time but, due to fiscal constraints, it has not been possible to acquire much-needed equipment and instruments at a rate adequate to replace aging and obsolete units. In addition, there have been operational deficiencies which stem from the historical orientation of the laboratories towards classical silicate analysis methods. The increasing shift from this towards more complex requirements, including analysis of ore- and sulphide-bearing samples, more accurate trace and minor element determinations and greatly increased total sample numbers, resulted in demands on the laboratories with which aging technologies were not able to cope. This situation is currently being addressed within EGM. The installation of the new simultaneous ICP unit has already made a major impact and sample backlogs are being reduced. Funds permitting, the aging (10-year old) non-automated XRF unit will be replaced with a state-of-the-art instrument in 1985/86 (Recommendation R4.3.2.2.1).

Three other recomendations (R4.3.2.2.2; R4.3.2.2.3 and R4.3.2.3.1) relate to the chemical laboratories. The first (contracting out) is a subject that is under continuing scrutiny in a variety of areas within GSC. In principle GSC endorses this from the viewpoint of offloading some of the routine workload (including both routine and complex matrix types) on the laboratories, and in fact currently does contract out substantial numbers of analyses. GSC has learned, however, from experience in other areas that the savings and advantages are not always as real as they are apparent. GSC frankly queries the statement, as a generalization, in the Committee Report that "...commercial laboratories...can provide excellent analytical results at a fraction of the cost with a faster turnaround than a government laboratory" (emphasis added). It may also be appropriate to note here that many analytical procedures currently in use in commercial laboratories (including XRF and AA methods) were originally developed or refined (AA) in GSC laboratories. This component (investment in future techniques) can thus be one of the benefits of in-house laboratory facilities. Nevertheless, GSC will pursue this matter internally. The subject of the second recommendation (R4.3.2.2.3 -internal costing of analytical work) is currently under examination by laboratory management. Again, it is reasonable in principle but experience in other areas has shown (notwithstanding the university experience cited in the report) that the process can tend to erect an internal 'bureaucracy' that may defeat its purpose. Nevertheless, the existing internal Laboratory Users Advisory Committee will examine this question seriously.

On the last recommendation in this series (R4.3.2.3.1 - possible combination of RGG and EGM chemical laboratories) GSC is not willing to make a commitment at this time. The two laboratories in question serve different needs within GSC, were established for different purposes and, at the moment do not result in duplication or significant overlapping of effort. The RGG laboratory contributes significantly to EGM research projects and vice versa. In 1983/84 for example, about half of the samples analyzed by EGM chemical laboratories were submitted by RGG Division. There is undoubtedly potential for funtion Collaboration but GSC prefers a more cautious approach here, and wishes to first introduce improvements in the chemical laboratories through new technologies and changes in operating procedures.

TIMELINESS AND OBJECTIVES OF MINERAL DEPOSITS RESEARCH

The Committee devotes some discussion and at least two recommendations (R4.3.2.12.1, R4.3.2.13.1) to what can be considered the broad question of whether to focus research effort on current and topical subjects or whether to focus on longer term, more fundamental aspects. Ideally, a mix of the two extremes is preferable, but the pressures of 'service' demands do not always allow total flexibility in this area. In its present research efforts GSC can point, for example, to work on seafloor hydrothermal sulphides as an example of the former (new and topical areas) and to theoretical modelling of ophiolite- and volcanic-associated hydrothermal processes as an example of the latter (longer term, fundamental understanding). This dilemma is difficult, and one that frequently confronts agencies such as GSC in attempting to obtain the best returns from application of resources. Recommendations R4.3.12.1 and R4.3.2.13.1 relate to this question. Uranium can be taken as a case in point (R4.3.2.12.1). Although it is true that exploration for uranium is currently at a low ebb, due to soft demand and uncertainties about the future of nuclear power generation, it cannot necessarily be assumed that this situation will continue indefinitely into the future. To a similar degree the same argument could be (currently) mounted for most major base metal commodities and iron ore. It would seem to be, however, shortsighted to terminate research in these commodity/deposit type areas on the basis of what is, hopefully, a relatively temporary situation. The same general arguments can be applied in the case of recommendation R4.3.2.13.1 (Theoretical Modelling). The conduct of sophisticated theoretical (and simulation) modelling presupposes the existence of a considerable body of data relating to the deposit type or processes being investigated, particularly if modelling is to yield results useful in general application. In the case of gold, for example, the general consensus appears to be that even accurate and useful (in a predictive sense) descriptive models for gold deposit types are so poorly understood, that 'theoretical' modelling of deposit-types or processes rests at best on infirm foundations at the present stage. Nevertheless the point implicit in the Committee's recommendation (R4.3.2.13.1) is taken that integrating of scientists working on theoretical modelling of processes at a relatively early stage in investigations is desirable. This aspect is further discussed in a following section ("Integration").

The Committee has further addressed this general question in the section 5.1 of the report dealing with "Future Mineral Deposits Research -Mechanisms for Setting Objectives" (especially) where, for example, it asks the (rhetorical) question - "Should the commodities of which Canada has an abundance be emphasized or should those commodities in which Canada is apparently deficient receive most emphasis?") It (the report) goes on to pose a number of similar questions, finishing with the observation that - "There are also strategic, regional and social policies to be considered". Taken all and all this series of questions (to which there are no definitive answers; merely opinions) is a nutshell illustration of why, in a very large country, a national agency (GSC) with relatively slim resources and an obligation to balance off research priorities against service priorities, faces an inherently insoluble task in setting research objectives that can satisfy all (sometimes conflicting) opinions.

It is not intended here to suggest that the sort of questions posed by the Committee with regard to research objectives are irrelevant or unimportant. They are crucial

questions and deserve and are given serious consideration. In the context of mineral deposits and metallogenic work, GSC has tried to apply a considerable part of its resources to the investigation of deposit types and geological environments that have traditionally yielded Canada's principal mineral trade commodities. At the same time, attempts have been made to divert significant research efforts toward new deposit types/commodities in response to perceived trends in exploration and commodity demand. Recent cases in point have been the formation of internal groups to work seriously on mafic-ultramafic associated commodities such as chromium and platinum group metals and gold deposits in various environments[1]. Currently, internal discussions are taking place on the question of whether or not new research thrusts into the geological aspects of the so-called 'rare metals' are appropriate.

These same sorts of questions can be posed in a regional context as well as in a commodity/deposit type context. GSC has been criticized in the past for not taking opportunities to quickly mount concentrated, integrated investigations in new and active exploration play areas. Hemlo (Ontario) is a recent case in point. In general, however, GSC's attitude has been that in cases where company activity is intense, proprietary information is extremely sensitive and land-holding situations are fluid and commonly unsettled, it is more appropriate to wait until the exploration situation has stabilized somewhat before embarking on large scale investigations. This philosophy has not, of course, prevented the conduct of legitimate research by individual scientists in active areas in cooperation with company personnel.

THE (GEOLOGICAL) FOCUS OF MINERAL DEPOSITS RESEARCH

This topic is closely related to the points discussed in the foregoing section. Two recommendations in particular (R5.3.2.1, R5.3.2.3) are directed at the question of the organization and focus of research. 'Camp' studies (R5.3.2.1) are without question useful and desirable and GSC endorses the principle here. The usual constraints of limited manpower and budgets are factors, as are jurisdictional questions (provincial agencies, for example, may prefer to focus on camp studies within their particular jurisdictions); nevertheless it is foreseen that there will be increasing opportunities for integrated co-operative projects in this area. There have been a number of successful prototypes, as for example, the joint GSC(RGG)-Saskatchewan Geological Survey-Industry Athabasca Project and collaborative studies of the Buchans Camp, Newfoundland and the Lynn Lake belt, Manitoba under federal-provincial co-operative agreements between EMR and the Newfoundland Department of Mines and Energy and the Manitoba Mineral Resources Division, respectively. It is anticipated that the new series of federal-provincial Mineral Development Agreements (ERDAs) with various provinces will provide new opportunities for collaborative research projects of this (camp study) nature.

Recommendation R5.3.2.3 (placing of mineral deposits geologists at selected 'key' deposits) is perhaps more controversial. GSC notes the generally favourable response to this suggestion received by the Committee in its questionnaire returns (with provincial exceptions) and endorses the general principle. At the same time, pragmatic difficulties in this approach are recognized, some of which have been noted by the Committee itself. This process would require the long-term dedication of scarce resources to very highly focused (geographically and geologically) effort and there would be obvious opportunity costs involved. At the moment, the GSC view is that specific opportunities for this type of project should be examined as they arise and that a more appropriate mechanism would be the focus of collaborative university-industry-government research efforts on candidate deposits to develop the type of continuing case-history documentation that the Committee seeks. It should be noted in passing that this approach has been taken in certain specific instances in the past, where appropriate opportunities arose. A recent case in point has been the 3-year continuing study of the Lupin (Contwoyto Lake) gold deposit by a member of the Mineral Deposits Geology Section of EGM.

INTEGRATION AND COLLABORATION

The theme of integration and collaboration (both within GSC and between GSC and other sectors) runs throughout the Committee report and is encapsulated in a number of its recommendations; R4.3.2.1.1 (major capital equipment); R4.3.2.4.1 (mathematical geology group); R4.3.2.6.1 (mineral deposits data); R5.3.2.2 (integrated regional studies); R5.3.2.4 (collaboration between geochemists and mathematical geologists); and R5.4.1.1 (collaboration with provincial agencies and university groups). There can be little quarrel with any of these sentiments. Increasingly, recent trends within GSC have been toward the mixing of scientists of different specialties and disciplines to focus on research projects of a common theme. There are numerous examples currently in place within the agency and it is fully expected that this trend will continue.

[1] The latter (Gold Working Group) can be considered in part a response to criticism by the Committee concerning the degree of effort on gold (see Report, section 4.3.2.9 p. 40); however, discussions concerning the formation of this group were already underway at the time of the Committee's investigation.