INTERNATIONAL CONFERENCE OF GEOLOGICAL SURVEYS

National Geological Surveys in the 21st Century

PROCEEDINGS

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NATIONAL GEOLOGICAL SURVEYS IN THE 21ST CENTURY

Proceedings of the International Conference of Geological Surveys held in Ottawa, Canada in April 1992

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FOREWORD

This volume contains the formal presentations and record of discussions that took place at the International Conference of Geological Surveys (ICOGS) in Ottawa, April 12-14, 1992. The Conference was one of a series of events that were organized to commemorate the 150th Anniversary of the Geological Survey of Canada. The dates (April 12-14) were chosen to coincide with the date (April 14) in 1842 that William Edmond Logan (later Sir William) accepted the appointment to "undertake a geological survey of the Province of Canada". Thus, by some chronological curiosity, the Geological Survey of Canada celebrates its 150th Anniversary in the same year as the country celebrates its official 125th Anniversary.

ICOGS had two primary objectives. First it was intended to provide a forum for representatives of geological surveys and international geoscience organizations to discuss the major issues expected to engage their organizations over the next few years and to stimulate comparisons and exchanges of views on these issues. This objective led to the structuring of the conference around the five major themes that were expected to embrace most of the individual issues of concern. The first theme (Evolution of Geological Surveys) was specific to geological surveys as "institutions" at both national and regional levels. The other four themes (Resource Development and Environmental Protection; Resources for Society; New Concepts and Technologies in the Earth Sciences; and International Communication, Cooperation and Collaboration) were relevant to the geoscientific community as a whole and specifically pertained to the roles of geological surveys only as members of this larger community.

The second objective of ICOGS was to explore the possibility of the formation of a world organization of geological surveys. Based on preliminary discussions with colleagues in other institutions prior to ICOGS it was apparent that the issues of concern for many geological surveys were remarkably similar. It was further apparent that many of these issues, particularly as they relate to environmental geoscience applications, are truly global in interest and, potentially at least, in impact. Thus, it seemed that an occasion such as ICOGS might usefully serve as a springboard to discuss a communal response to the problems and challenges facing geological surveys around the world.

The results of the first objective of ICOGS are compiled in the pages that follow. In both the formal and informal presentations recorded in this volume a few principal conclusions are evident. The first is that the traditional roles and "cultures" of geological surveys are changing rapidly to accommodate new demands for services and products that can be directed at current societal needs. This is manifested most clearly in the preoccupation with putting in place programs and projects in environmental geoscience to address issues such as water pollution, geomedicine, environmental geochemistry, natural hazard impact reduction and the like. A counterpoint to this trend is the cautionary conclusion that the world will continue to consume mineral and energy resources and that a primary role for geological surveys will continue to be the provision of up-to-date geoscience data bases to guide exploration for the replenishment of mineral and energy supplies.

Geological surveys thus find themselves in the position of needing to continue and even enhance their traditional roles in basic "core" geoscience programs such as geological mapping while at the same time taking on new responsibilities in delivering environmental programs. All of this must be accomplished, in the case of most organizations, with ever-diminishing funding levels. This dilemma of being caught between expanding responsibilities and shrinking budgets leads institutions to consider other ways of supplementing operating resources, including cost-recovery, revenue-generation and joint-venture mechanisms.

Another major conclusion concerns communications. There is a widespread awareness that, particularly in the newer areas of environmental applications, surveys will need to develop more effective communications techniques and networks, both externally towards clients and internally towards the policy and political levels of their organizations. Communication skills seem likely to become increasingly important assets in geoscience institutions of the future.

Finally, with respect to the second objective of ICOGS - the question of a possible world organization of geological surveys – there was discussion but not resolution. The question was left open but there was a recommendation to pursue the matter further, perhaps at the 29th International Geological Congress at Kyoto, Japan in late August of 1992.

Looking back, ICOGS was an interesting first venture in attempting to garner the views of institutions from many parts of the world on a number of complex issues. As this volume records, there were consistent views on many of these issues, but much work remains to be done on others. Perhaps this can be the challenge for a future ICOGS.

D.C. Findlay
Ottawa, July 1992

ACKNOWLEDGEMENTS

Many people worked long and hard to plan and implement ICOGS. Members of the Program Committee and the various local arrangements Committees (see inside cover) are thanked for their conscientious efforts on behalf of ICOGS. Special thanks and appreciation are extended to Roy McLeod and Diane Bouchard who served as the collective Secretariat for the Conference. Through their dedicated and patient labours, ICOGS was translated from concept to reality. Alan Heginbottom stepped into the breach late in the day to look after speaker's needs and arrangements with professional skill and aplomb. Kathy Gareau contributed many hours preparing the database for invitations, mailing labels, and material for the Program and Abstracts volume for the meeting. Members of the Geological Survey of Canada's 150th Anniversary Committee, chaired by Robin Riddihough and orchestrated by Charles Smith and LeeAnne Frieday extended helpful support throughout.

The organizers are indebted to the organizations listed in the front of this volume for financial support in helping defray the costs of ICOGS. Their contributions are gratefully acknowledged. To the speakers, Commentators, Session Chairs and general participants at ICOGS, we extend our sincere appreciation for assuring that the Conference was a success. Finally, we thank John Scott, Jonathan Bramwell, and Heather Bramwell for compiling and editing this volume, and Annette Bourgeois and Mike Kiel and their staff at GSC Publications for guiding the volume through to print.

D. C. Findlay
Ottawa, July 1992

ADDENDUM

In conjunction with the International Geological Congress, a meeting of 52 representatives from 34 countries was convened in Kyoto, Japan, on August 25, 1992 to further discuss the question of a world organization of geological surveys. At this meeting, it was agreed that an informal "World Geological Surveys Committee" be established that would meet every four years (at the time of International Geological Congresses) and at some appropriate venue about mid-term between Congresses.

A Working Group was identified to prepare draft terms of reference and to plan for the next meeting. Dr. Henk Schalke, Geological Survey of The Netherlands and a representative of WEGS (Western European Geological Surveys) was named as Secretary of the Working Group.

International Conference of Geological Surveys

D.C. Findlay[1], E.A. Babcock[2], and R. Riddihough[3]

WELCOME/INTRODUCTION

Dr. Findlay welcomed the delegates to the International Conference of Geological Surveys. After some preliminary remarks regarding general conference matters and arrangements, Dr. Findlay introduced Dr. E.A. Babcock, Assistant Deputy Minister, Geological Survey of Canada to officially open the meeting.

E.A. BABCOCK

It gives me great pleasure to officially welcome you to the International Conference of Geological Surveys on behalf of the Geological Survey of Canada. We are pleased that we have reached the ripe age of 150 years which is 25 years older than Canada itself. We look forward to the next 150 years.

We are pleased to see so many of you here from other countries and other institutions. We are fully aware that in these difficult times it is not all that easy to find travel funds. Thus we are doubly appreciative to those of you who came from long distances to participate in this conference on the future of geological surveys, to help us celebrate our Anniversary, and to discuss common challenges and problems.

As we have at the GSC, many of you have probably recently been going through thinking and planning processes regarding the future of your organizations. You will have found, as we have, that this is not an easy process. It is made difficult because the world around us is changing so quickly. Established orders and ways of doing things that we have been accustomed to for many years can no longer be taken for granted. To cite one example, most of us are familiar with the seemingly never-ending squeeze on resources that has been driving us towards seeking different mechanisms of operation and different sources of funding.

All of us are experimenting with new ways to stretch resources and cost-recovery is now a part of everyone's vocabulary. For us at the GSC, we have gone beyond the point of "doing more with less", and we are now concentrating on building collaborative relationships with industry and provincial surveys in order to stretch the resources available in Canada for the earth sciences.

Other changes have also been taking place. Most of us from industrialized countries are finding that our client base is changing. Our traditional focus on supporting resource exploration and exploitation is still very much evident; however, increasingly we are concerned also with environmental matters. At last, the various scientific disciplines are learning to work together to tackle environmental issues; furthermore, government policy makers are also coming to realize that virtually all environmental problems have an earth science component. Policy makers now realize that the solutions to many environmental problems lie in understanding geological processes - both ancient and modern; obvious processes like earthquakes and subtle ones like geochemical pathways.

We who are heads of national surveys must broaden our horizons to accommodate the concept of global science performed by a global community of scientists, because geology and geological processes ignore political boundaries. The global laboratory concept has always been an important part of geoscience research, and current

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programs like the Ocean Drilling Project, supported by many countries and dealing with global scale research attest to this. We will need to expand the global laboratory concept, particularly in the domain of studying earth systems. Such studies will provide governments with the knowledge to aid in formulating progressive policies for resource management and for land use and environmental stewardship matters.

We have invited you here not only to help us celebrate 150 years of the Geological Survey of Canada, but also to have a substantive discussion about the new challenges facing all geological surveys. This will be a chance to share ideas and experiences on both the present state and the future of geological surveys. In particular we will examine the evolving roles of national and state or provincial geological surveys in all regions of the world in both resource dependent countries as well as in more highly industrialized nations.

We will examine the role of geological surveys in reconciling resource development and environmental protection (sustainable development) and how changing resource uses will affect geological surveys.

We will examine how changes in our science will affect the future of geological surveys and finally, we will conclude with a discussion of means to enhance global collaboration in the earth sciences.

You have all travelled great distances to be here and to participate in the next two days of discussions and I am certain that you will find them to be interesting, provocative and useful in managing your geological survey, or in better understanding its role.

Many individuals have donated their time and effort in preparing presentations or commentary for this conference. Without their efforts this meeting would not be possible and I would like to thank them on behalf of all of us.

Let me again welcome all of you to Ottawa; and thank you for coming here to participate in the 150th Anniversary celebrations of the Geological Survey of Canada, one of the world's senior geological surveys.

Dr. Findlay thanked Dr. Babcock and then introduced Dr. Robin Riddihough, Chief Scientist and Chair of the Geological Survey of Canada 150th Anniversary Committee.

R. RIDDIHOUGH

I'd like to welcome everyone here tonight. Our 150th anniversary is a very important way of looking at where the Geological Survey of Canada has come from and why we are here and where we are going. On the 21st of April, 1842, exactly 150 years ago, William Logan wrote a letter of acceptance to the Government of Upper and Lower Canada saying that he would be pleased to be the Director of the Geological Survey. When he finally arrived two or three months later, it turned out that the appropriate government departments did not have the authority to issue a cheque to pay him. He finally came back about nine months later and it then turned out there was no building to put the Geological Survey in. He ended up renting a building from his brother. And so it went on. It is reassuring to know that governments have not changed much in 150 years.

I think it is true to say that this particular conference, of invited participants, is one of the more special things that we are doing this year: a chance to talk to other people about their Surveys, where they have come from, where they think they are going, how we move together into the future. There will be an official ceremony celebrating the Anniversary and a Gala night on Tuesday. We also have various other things going on throughout the year. For instance you will find if you buy Macleans Magazine in Canada over the next week (it is a kind of Canadian equivalent of Time or NewsWeek) that the GSC has a special advertising supplement in the middle with all sorts of wonderful comments about the Geological Survey. This is just one of many things that have been done to celebrate this 150th Anniversary and to help people understand us. This little book is a history of the Geological Survey. It's called "No Stone Unturned", or in French, "Pierre per Pierre". It is a very readable history of the Geological Survey. Please take one.

Coincidentally, the other preoccupation that I have had this year has been writing a Strategic Plan for the Survey. Working on the 150th Anniversary has given me a feeling of where we've come from, what we're doing and why, and where we fit into the country's history. It has been a very important background to developing a strategic look into the future.

I certainly look forward to the next two days. Does anybody understand what we do? Does anybody care? Why are all our budgets shrinking? I'm looking forward very much to hearing the answers.

National Geological Surveys: Their Present and Future Role

R.A. Price[1]

Price, R.A., National Geological Surveys: Their Present and Future Role; in National Geological Surveys in the 21st Century, Bouchard, D.S, et al. (compilers), Geological Survey of Canada, Bulletin 446, p. 3-10, 1993

Abstract

To govern, governments require information.

Geoscience information is required by national governments for the development of sound public policies on, among other things: mineral and energy resource development; the management of risk due to geological and geophysical hazards such as floods, landslides, earthquakes and volcanic eruptions; and the protection of the environment, nationally and globally.

Geoscience information is also used by governments as an instrument of public policy. For example, it is made available by governments to the general public, or to specific target audiences, in order to stimulate regional or national development of mineral or energy resources, to reduce the risk due to natural hazards, or to promote environmentally sound economic development.

National geological surveys have been established in most countries to ensure that national governments have the geoscience information and expertise that they require for the development and the implementation of their public policies. Systematic geological (including geophysical and geochemical) mapping, along with other topical research by the national geological surveys is combined with geoscience information from many other industrial, state or provincial, and academic sources to generate the national geoscience knowledge base from which the required geoscience information and advice are extracted. The national geoscience knowledge base is an important national resource that will be depleted by the advancement of science if not continually updated. The time required for the research, including the systematic geological surveys, that will maintain the research, including the systematic geological surveys, that will maintain the vitality of the national geoscience knowledge base is longer than the lifetime of many national policy issues; and therefore good strategic planning is crucial to the effective operation of national geological surveys. Feedback relationships between the national knowledge base and those geoscience activities which are instruments for the implementation of public policies, offer important opportunities for maintaining and strengthening the knowledge base.

Geoscience information and expertise is a special kind of national resource. Unlike many other kinds of scientific information and expertise, it has both local and universal significance. It pertains to a specific place in a specific country as well as to the global corpus of scientific knowledge. It is part of the knowledge base concerning the nature and present state of a country. Along with information on the rest of the natural environment, on the size and nature of the national population, on the economy, and on the national and political environment, it forms and integral part of the information framework within which governments govern.

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Geoscience information and expertise that is acquired to meet the requirements of national governments for the development of policies, can be made available to the general public at low added cost. Thus it is commonly treated as a marketable commodity, but sold at reduced prices in order to communicate with specific target audiences such as mineral and energy resource development companies that might stimulate regional economic development, or with citizens who are threatened by the risks associated with natural hazards such as earthquakes and flooding. It may also be treated primarily as a source of national revenue, and sold at market prices to resource development companies, consultants, and geoscience service companies. In some countries the role for the geological survey has been shifting away from service to the government and to the general public,toward the sale of professional services and geoscientific information on the open market in competition with non-governmental organizations. In a free enterprise society this trend must inevitably lead to the demise of the geological survey.

To be effective in the public policy process, geoscience information and advice must be user-friendly and credible. It must be timely, succinct, and completely understandable in terms of its significance, scope, and limitations; and that at the same time, it must meet the highest standards of scientific quality and credibility. This can only be achieved by maintaining an open dialogue between the geoscientists and the people who will use their information and expertise, and by employing both the best available scientific talent, and a thorough scientific peer review of the scientific data and of their interpretation.

Since the first national geological survey was created in Great Britain, just over 150 years ago, national geological surveys have been established in most countries throughout the world to ensure that governments have the geoscience information and expertise that they need to do their job. The basic purpose and scope of the national geological surveys has not changed much over the years, but relative importance of the various applications of geoscience information and expertise has changed, and is changing rapidly now, on a global scale, as well as on the scale of the individual nation. There is a shift in emphasis from resource exploration and development to public safety and security, and to protection of the environment, particularly the global environment.

Rapid advances in the development of new technologies is also driving changes in the focus of geological surveys. New, rapid, relatively low-cost, high precision observational and analytical technologies have created new opportunities for the acquisition of geophysical, geochemical, and geochronological data that have transformed the geoscience of the continents, offering the prospect of major advances on problems such as extending geological surveys down into the third dimension, depth, where they can address fundamental problems such as the search for deeply buried mineral resources, the storage of toxic wastes, and the clean-up of contaminated groundwater systems, and back into the fourth dimension, time, particularly Precambrian time, the first four-fifths of Earth's history, which lacks adequate fossils for precise biostratigraphic dating.

Emerging global crises arising from growth in the human population, the per capita use of resources, and the resulting depletion of natural resources and deterioration of the environment for human habitation will present governments worldwide with urgent needs for geoscience information and expertise about areas both within and beyond their national borders. The potential future role for national geological surveys is very large; the actual future role will depend on many factors, not the least of which will be the leadership displayed by national geological surveys individually and collectively.

Résumé

Pour gouverner, les gouvernements ont besoin d'information.

Les gouvernements nationaux ont besoin d'informations géoscientifiques pour formuler de bonnes politiques générales dans des domaines comme la mise en valeur des ressources minérales et énergétiques, la gestion des risques posés par des dangers géologiques et géophysiques comme les crues, les glissements de terrain, les séismes et les éruptions volcaniques, et la protection de l'environnement à l'échelle nationale comme à l'échelle mondiale.

Pour être vraiment utiles à la formulation de politiques générales, les informations et les conseils géoscientifiques doivent être dignes de foi et d'un abord facile. Cela veut dire qu'ils doivent être à jour et succincts et qu'ils ne doivent laisser aucun doute quant à leur importance, leur portée et leurs limites. Par ailleurs, ils doivent répondre aux normes les plus élevées de validité et de crédibilité scientifiques, ce dont on ne peut s'assurer qu'en ayant recours aux plus grands esprits scientifiques et en soumettant les données scientifiques et leur interprétation à un examen confraternel approfondi.

L'information et les compétences géoscientifiques représentent par ailleurs un type spécial de ressource nationale. Contrairement à d'autres types d'information et de compétences scientifiques, elles revêtent une importance à la fois locale et universelle. Elles s'appliquent à un point précis d'un pays donné, mais ajoutent en même temps au savoir scientifique mondial. Elles font partie de la base de connaissances sur la nature et l'état actuel d'un pays, qui, avec les informations sur l'économie, sur la taille et la nature de la population, etc., et sur le milieu naturel, constitue le cadre d'information sur lequel les gouvernements s'appuient pour gouverner.

Les gouvernements utilisent aussi les informations géoscientifiques comme instrument de politique générale en les mettant à la disposition du public en vue, par exemple, de stimuler la mise en valeur des ressources, de réduire les risques posés par les dangers naturels ou de promouvoir un développement économique national qui soit compatible avec l'environnement. L'information géoscientifique obtenue pour satisfaire les besoins des gouvernements nationaux peut être mise, moyennant des frais modiques, à la disposition du grand public. Elle est donc traitée souvent comme un produit commercialisable, qui peut être vendu au rabais pour atteindre une certaine clientèle, par exemple les entreprises de mise en valeur des ressources minérales et énergétiques, qui peuvent stimuler le développement économique, ou des citoyens que menacent les risques posés par des dangers naturels comme les séismes et les crues. On peut également la traiter avant tout comme source de recettes nationales en la vendant, aux prix du marché, aux entreprises de mise en valeur des ressources, aux experts-conseils et aux entreprises de services géoscientifiques. Dans certains pays, les commissions géologiques se consacrent de moins en moins au service du gouvernement et du public pour s'orienter de plus en plus vers la vente de services professionnels et d'informations géoscientifiques sur le marché libre, en concurrence avec le secteur privé. Dans une société de libre entreprise, cette tendance devrait mener inévitablement à la ruine des commissions géologiques et à la privatisation de leurs fonctions.

Depuis la création de la première commission géologique en Grande-Bretagne, il y a un peu plus de 150 ans, la plupart des gouvernements ont établi des commissions géologiques pour pouvoir disposer des informations et compétences géoscientifiques dont ils ont besoin pour gouverner. L'objectif fondamental et le champ d'action des commissions géologiques nationales n'ont pas vraiment changé au fil des années, mais l'importance relative des diverses applications de l'information et des compétences géoscientifiques a évolué et évolue rapidement aujourd'hui à l'échelle mondiale, ainsi qu'à l'échelle de chaque pays. Au lieu d'être placé sur la prospection et la mise en valeur des ressources, l'accent est maintenant mis sur la sécurité publique et sur la protection de l'environnement, en particulier sur celle du milieu naturel mondial.

Le progrès rapide de la technologie contribue, lui aussi, à réorienter la fonction des commissions géologiques. La rapidité, le prix relativement faible et la grande précision des technologies d'analyse ont ouvert de nouvelles possibilités d'acquisition de données géochimiques, géophysiques et géochronologiques, qui ont transformé la géoscience des continents, et offrent la perspective de grands progrès dans l'étude de problèmes fondamentaux comme la recherche de gisements profonds, l'entreposage de déchets toxiques et la décontamination des eaux souterraines polluées.

Vu les nouvelles crises mondiales que provoquent la croissance démographique, l'utilisation des ressources et la détérioration de l'environnement pour l'habitation humaine, les gouvernements du monde entier auront, de toute urgence, besoin d'informations et de compétences géoscientifiques " l'échelle de leur territoire et au-del". Les commissions géologiques nationales pourraient jouer un rôle très important à l'avenir, mais ce rôle dépendra de nombreux facteurs, dont l'un des plus importants sera le leadership manifesté individuellement et collectivement par les commissions géologiques.

INTRODUCTION

It is a very special honour and privilege for me to lead off this conference marking the 150th anniversary of the Geological Survey of Canada.

The Geological Survey of Canada has been a dominant influence in my life ever since I received a letter, some 40 years ago this month, offering me a summer job as a field assistant on a GSC field party working in the Purcell Mountains of southeastern British Columbia. As a result of my experience during the 1952 field season, I switched my university program from physics and chemistry to geology; and I became focused on the idea of a career in geological research, serving my country through the Geological Survey of Canada. It was a good decision. Employment as a GSC field assistant provided superb learning opportunities and practical experience during a number of subsequent summers. It led to a Ph.D. thesis project within the GSC's field program (a very advantageous arrangement, I found, when I knew of the circumstances of my fellow students in the United States), and eventually it led to a rewarding job as a research scientist with the Survey here in Ottawa.

Although I left my position with the GSC in 1968, to begin teaching at Queen's University, my association with the Survey continued through my research and that of my graduate students. When I returned to Ottawa in 1981, and assumed responsibility for management of the GSC, I became familiar with many other new and fascinating aspects of the GSC. This long association, and these experiences make me particularly pleased and proud to share in this celebration of the sesquicentennial of the Geological Survey of Canada.

My task today is to set the stage for the discussion on a central question of this symposium, which is: "What is the present and future role of national geological surveys?".

This is a very difficult question, because we live in a time of rapid and unexpected changes. The world is being transformed at a remarkable pace, and in unanticipated directions. The news media abound with stories about the threat of ominous global changes in the geosphere and the biosphere that are attributed to the cumulative result of human activities. The present rate of growth in the human population, in natural resource utilization, and in human impacts on the environment for life on Earth is unique in the entire history of humankind. Environmental impacts are assuming increasing importance in policy making everywhere. Patterns of natural resource exploration, production, and utilization are now changing in response to their environmental consequences as well as to shifting markets. New technologies have transformed the nature, the scope and the effectiveness of the activities of the geological surveys. It seems that the past is no longer a reliable guide to the future. Moreover, under the present rapid pace of change, the distinction between the present and the future is becoming blurred; and the present role of national geological surveys is coalescing with their future role, which now truly begins tomorrow. In viewing my task from this perspective, I am reminded of the proverb: "To prophesy is extremely difficult -- especially with respect to the future". Accordingly, rather than attempt to address face on the question of the present and future role of geological surveys, I will consider some other basic questions first:

-Are national geological surveys required in our modern world, or are they unnecessary vestiges of a former era?

-What should governments expect in return for using scarce financial resources to meet the costs of maintaining national geological surveys?

-Does the basic purpose of a national geological survey differ significantly from one country or region to another? or are there generalities that apply globally?

Let me first consider some generalities.

THE MISSION OF A NATIONAL GEOLOGICAL SURVEY

To govern, governments require information.

Governments require information in order to identify and analyze national problems and opportunities, to make sound public policy decisions, and to implement those decisions. To be most effective, the information must be impartial and trustworthy; and moreover, in a democracy, the essence of the information also must be available and understandable to the people on behalf of whom the governments act, and to whom they are accountable.

Geoscience information is required by governments for the development of sound policies on, among other things: the management of mineral, energy and water resources; the management of risk due to geological and geophysical hazards such as floods, landslides, earthquakes and volcanic eruptions; and the protection of the environment and human health, nationally and globally.

Geoscience information is also required by governments for use as an instrument of public policy. For example, it is made available by governments to the general public, or to specific target audiences such as the mineral or petroleum exploration industries, in order to stimulate regional or national development of their natural resources. It is made available to the general public to reduce the risk due to natural hazards. And it is made available generally to promote environmentally sound economic development.

Geoscience information and expertise is a special kind of national resource. Unlike many other kinds of scientific information and expertise, it has both local and universal significance. It has local significance because it pertains to a specific place in a specific country, as well as to the global corpus of scientific knowledge. It is part of the knowledge base concerning the nature and present state of a country. Along with information on the rest of the natural environment, on the size and nature of the national population, on the economy, and on the national and international political environment, it forms an integral part of the information framework within which governments govern and nations function.

To function effectively a nation needs a source of impartial and scientifically trustworthy geoscience information and expertise. National geological surveys meet this need by conducting field research and related laboratory research, by compiling information available from state or provincial agencies, universities, industry and various other sources, and by using all of this to maintain a national geoscience knowledge base from which the required geoscience information and advice can be extracted as required. The national geoscience knowledge base is an important national resource; but it becomes depleted with the advancement of science, if it is not continually updated. The time required for the research, including the systematic field surveys, that will maintain the vitality of the national geoscience knowledge base is longer than the lifetime of many national policy issues; and therefore good strategic planning is crucial to the effective operation of national geological surveys. Feedback relationships between the national knowledge base and those geoscience activities which are instruments of policy offer important opportunities for maintaining and strengthening the knowledge base. These various considerations are the basis for my convictions concerning the need for, and the purpose of, a national geological survey.

In short, the basic mission of a modern national geological survey is to ensure the availability of the geoscience information and expertise that is required for the wise use of the nation's mineral, energy and water resources, for the health and safety of its people, and for the protection of the environment.

AN HISTORICAL PERSPECTIVE

Since the first national geological survey was created in Great Britain, just over 150 years ago, national surveys have been established in most countries throughout the world. The geological surveys provided scientifically verifiable information and expert advice to governments, and they have served as national instruments for promoting investment in, and development of, mineral and mineral fuel resources.

The scope of the work of the national geological surveys, and the relative importance of the various applications of their geoscience information and expertise have changed dramatically over the years, but their basic mission remains unchanged. The romantic era of preliminary geological exploration of vast new areas, and the search for easy-to-find mineral and energy resource bonanzas has been replaced by a new era of technologically sophisticated research, commonly conducted by large interdisciplinary teams or networks. State and provincial geological surveys, the universities, and exploration research components of mining and petroleum companies have made increasingly important contributions to national requirements for geoscience information and expertise; however, none of these agencies can be completely committed in the nature and scope of their work, to fulfilling the national requirements, because they all must "march to the beat of a different drummer". Growing concerns about water resources, environmental constraints on economic development, the impact of human activities on the environment and public health, and public safety have created new demands for national geoscience information and expertise, and new tasks for national geological surveys. But in spite of all of these new developments, the basic mission of a national geological survey can still be described as "to ensure the availability of the geoscience information and expertise required to promote the wise use of the nation's natural resources, and the safety, health and well being of its people".

FUTURE NEEDS

Environmentally sound resource development to meet the needs of explosive growth in the human population, and the needs for reduction of risk to human health and safety are both important policy issues in our current climate of rapid and unexpected changes. They most certainly will be preeminent policy issues in the near future as both the human population and the demand for global sustainable development continue to grow. In order to illustrate what I mean, I would like to point out that when I began working for the Geological Survey of Canada the size of the human population was about 2 1/2 billion; just before I retired it had passed 5 billion. More people had been added to the human population during that thirty-five-year period than during all of the preceding history of humankind; and furthermore, during that period there also was a substantial growth in the per capita use of mineral and energy resources, and in the per capita contribution to the degradation of the global environment. Barring some global catastrophe, it seems inevitable that as we move into the twenty-first century, there will be continued growth in the human population, in the demand for energy, mineral and water resources, and in the threat to human safety, health and the environment for life on Earth. Accordingly, I believe that it is safe to conclude that the need for an impartial, trustworthy national source of geoscience information and expertise will grow in the immediate future in every major country in the world, and that the reconciliation between resource exploration, production and utilization on one hand, and the protection of the environment on the other, will be the central issue inducing changes in what geological surveys do and how they do it.

OPPORTUNITIES

Rapid advances in the development of new technologies will also drive changes in the activities of geological surveys. New, rapid, relatively low–cost, high precision observational and analytical technologies have created new opportunities for acquiring geophysical, geochemical, and geochronological data that have transformed the science. They offer the prospect of major advances on fundamental problems such as extending geological surveys into the third dimension, depth, where they can address fundamental problems such as the search for deeply buried mineral resources, the storage of toxic wastes, and the clean–up of contaminated groundwater systems, and also back into the fourth dimension, time, particularly Precambrian time, the first four-fifths of Earth's history, which lacks adequate fossils for precise biostratigraphic dating. New technologies for the storage, retrieval, analysis and display of data, particularly the geographically referenced data that are the main concern of geological surveys, offer extraordinary opportunities for improving the effectiveness of the geological surveys in the performance of their research and in communicating with their clients. Geographic information systems and high-speed digital data transmission capabilities are revolutionizing the way geological surveys operate.

CHALLENGES

Geological mapping has been, is now, and will be a primary activity of national geological surveys as they enter the twenty-first century. It is unfortunate that "geological mapping" is an activity whose real nature is concealed by its name. Contrary to what may be implied by the term "mapping", geological mapping is a basic field research activity. It involves the use of a variety of techniques from the most mundane to the most sophisticated new technology; but whatever the technique its basic purpose is to establish the nature, the three dimensional shape and position, the origin, the age and evolution, and the regional or global significance of bodies of rock. It involves the recognition, description, analysis and interpretation of experiments that have been conducted by nature, and that hold the key to the wise use of the Earth by mankind.

The new frontier for geological mapping is the third dimension - depth. In the past most geological mapping has been essentially two dimensional; limited to what is exposed at the Earth's surface, revealed by scarce boreholes, or inferred by projections into the subsurface. Emerging new technologies for geophysical remote sensing, like those which transformed the petroleum exploration industry, offer the prospect of dramatic advances in the mapping of the geology at depth; and this offers the prospect of major new mineral resources. For example, over vast areas of the continents basement rocks like those which have provided much of the world's mineral wealth, are buried beneath younger sedimentary rocks, but occur at depths at which they could be mined if the mineral deposits that they contain could be identified. One of the challenges for the emerging new technologies is to find those new mineral resources.

INFORMATION AND COMMUNICATION

National geological surveys are in the geological information business. They exist to meet the geoscience information requirements of the nation, as defined and re-defined from time to time by the government. Their welfare and their survival are contingent on their success in identifying and satisfying the needs of their clients.

To be effective in the public policy process, geoscience information and advice must be user–friendly and credible. It must be timely, succinct, and completely understandable in terms of its significance, scope, and limitations; and, at the same time, it must meet the highest standards of scientific quality and credibility. This can only be achieved by maintaining an open dialogue between the scientists and the people who will use their information, by employing the best available scientific talent, by fostering scientific creativity, and by ensuring thorough scientific peer review of the science. Public policy issues demand specific, quantitative, "derivative" geoscience information, such as assessments of the resource potential of a region or the earthquake risk in a specific area, or the expected oil and natural gas endowment of an entire nation. Systematic impartial, authoritative geoscientific studies provide the only rational basis for answering these questions; but the time required to conduct the necessary research is commonly much longer than the duration of the public policy issue, or of a specific government. Consequently, it is vital that challenges, problems, and opportunities be anticipated, and that financial and human resources be deployed strategically.

Good strategic planning is crucial to the effective operation and survival of national geological surveys. Strategic planning must seek to ensure the availability of the knowledge and the expertise that will be required to address the policy issues that will emerge in the future. It involves taking into consideration new or emerging policy directions, new or emerging scientific concepts that may lead to a re-evaluation of existing scientific data or to the need for new data, and it also involves providing for the availability of the professional expertise that will be needed in the future. Geoscience expertise is generally developed through experience gained while studying specific areas or regions; and therefore, it is not entirely portable, nor can it be generated rapidly to meet new demands. Successful investments in the development of professional expertise require great foresight and careful planning.

Geoscience information and expertise that is acquired to meet the needs of national governments for the development of policies can also be made available to the general public at low added cost. Geoscience information may be provided free of cost as a "public good", or it may be treated as a marketable commodity, but sold at reduced prices, when it is used as an instrument of public policy to influence specific target audiences such as mineral and energy resource exploration companies that might stimulate regional economic development, or such as citizens who are threathened by the risks associated with earthquakes and flooding or other natural hazards. However, geoscience information and expertise also may be treated primarily as a source of national revenue, and sold at market prices to other government agencies, to resource development companies, to consultants, or to geoscience service companies. In some countries the role for the national geological survey has been shifting away from service to the government and to the general public, toward that of a profit centre based on the sale of professional services and geoscientific information on the open market in competition with private companies, but with the benefit of government funding. In a free enterprise society this trend is risky at best, because inevitably the customers, and particularly the government, who pay most of the costs of operation of the geological surveys, will expect full value for the money that they spend.

CONCLUSIONS

National geological surveys are in the geological information business. They exist to meet the geoscience information requirements of the nation, as defined, and re-defined from time to time, by the government. The welfare and survival of geological surveys are contingent on their success in identifying and satisfying the needs of their clients.

The twenty-first century will provide new challenges and new opportunities for national geological surveys. Emerging global crises arising from the growth in the human population and the per capita use of resources, and the resulting depletion of natural resources and deterioration of the environment will present governments worldwide with urgent needs for geoscience information and expertise about areas both within and beyond their national borders. The potential future role for national geological surveys is very large; the actual future role will depend on many factors, not the least of which will be the leadership displayed by the national geological surveys individually and collectively.

ACKNOWLEDGEMENTS

My views on the present and future role of national geological surveys originate with my experiences in the management of the Geological Survey of Canada, where they were strongly influenced by John Fyles, Bill Hutchison, and Digby McLaren, but they also reflect helpful comments provided in response to written requests from me by: E-an Zen, Brian Skinner, Roye Rutland, Dallas Peck, Martin Kürsten, Umberto Cordani, and Peter Cook, all of whom will recognize some of their words in what I have said tonight. Thank you very much.

CHARLES SMITH[1]:

It's my pleasure to thank Ray Pice on your behalf for an eloquent and challenging opening comment to this conference. I think he has set the stage very well for the discussions and if things continue at the high standard that he has set we're going to get some useful results. He has raised a number of questions on the future role of national geological surveys. He gave a statement of opportunity- the potential future role for national surveys is very large. There are many new challenges and new opportunities. And he has also issued a challenge, when he said the actual future role will depend on many factors, not the least of which will be the leadership displayed by national geological surveys individually and collectively. Leadership in terms of a national survey is not a simple task. It's not a job for the fainthearted. The working environment of a geological survey is continually changing. Dr. Price made frequent remarks to change. Dr. Babcock referred to the political and financial changes that are impacting on the surveys. The client base is also changing, as he said. The geoscience knowledge base, the available geoscience data and especially the interpretations of those data are continually being upgraded and reinterpreted. Reference was also made to the changingtechnologies for collecting, processing and presenting Earth Science data.

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As well, the public policy demands on geological surveys are continually changing. Over the past decades, there have been changes in emphasis from resource availability, to energy needs, water availability, environmental protection, and now sustainable development. Perhaps new issues will emerge for policy purposes and for direction of geological surveys during the 21st century. Another important area for change over time has been the institutional setting of a national survey within its national borders. When Sir William Logan started his work in Canada, he was the national survey. There were no other public spokespersons for earthsciences at that time. Now, as in many other countries, there are a multitude of bodies involved in the Earth Sciences, including the mining companies, provincial surveys, university departments and other federal and national institutions. Dr. Price pointed out that none of them can assume the national role of a geological survey, but they have a significant role to play. This requires a continual conscious effort on behalf of national surveys to seek closer collaboration with other institutions, to share scarce financial and manpower resources, and to work jointly to ensure that the earth sciences truly serve the inhabitants of this country and of this planet; and Dr. Price mentioned several major national projects that are underway in Canada now that fit this situation.

In this context, I am truly proud of the leadership that the Canadian Geological Survey has shown in the past, and I expect that this Conference will promote discussion and ideas on how to tackle the future. Thanks very much for starting us down that road tonight.

Welcoming Address

B. Howe[1]

It is a pleasure to welcome you here on behalf of the Department of Energy, Mines and Resources, and the Geological Survey of Canada, your hosts for this meeting. Je veux vous souhaite la bienvenue au Canada, à Ottawa et à la Conférence internationale des commissions géologiques.

Comme vous le savez, cette réunion fait partie d'une série d'activités qui, en cette année 1992, sont organisées pour commémorer le 150[e] anniversaire de la Commission géologique du Canada. Cet anniversaire représente beaucoup pour nous, nous en sommes fiers et nous tenons à ce qu'il soit célébré officiellement au Canada.

As you know, this meeting has been organized as a part of a series of events that will in 1992 commemorate the 150th birthday of the Geological Survey of Canada. We are very proud of this important anniversary. We're so proud, in fact, that we had a record snowstorm on Saturday to remind all of you who are geologs that out there in the real world there is a tough thing called the landmass in this country that for a good chunk of the year is covered with snow. And so I guess you could say that we started the celebrations in an appropriate Canadian style.

You will understand, I am sure, when I say that governments seem not always fully aware of the important role that geological surveys have played in the evolution of our countries. This role will be particularly well understood by you in this audience but it is a point that is not always appreciated outside of your professional community. So, at Energy, Mines, and Resources Canada, we have been trying to make 1992 into a year of both education and public awareness about the importance of geoscience knowledge to modern societies in general and in particular about the role that the Geological Survey of Canada has played in this country.

The Geological Survey, notwithstanding its 150 years, is not the oldest survey in the world. The British are older - one might say they always are in a major way - and I think that there are one or two U.S. state surveys that exceed us in longevity. One is our neighbour immediately to the south in New York. We are extremely pleased that these representatives of the distinguished Senior Citizens of the Geological Survey world are with us here today.

For people like me who are not geologists, but who are acquainted with wonderful institutions like the Geological Survey of Canada, it is sometimes difficult. When you first encounter the organization you tend to look at it with a certain quizzical air and then you try to figure out what it is all about. It slowly dawned on me that for the Geological Survey of Canada, the best analolgy that comes to mind is that it's like the Society of Jesuits, superbly trained for a chosen vocation. A geologist does not have a job; in the past he had a calling and now he or she has a calling. So I tell people that the analogy that comes to mind is that the Geological Survey of Canada is like the Society of Jesuits.

I was in Washington recently calling on Dallas Peck. I tested this theory and I said, "You know, Dallas, I keep telling our people in the Geological Survey of Canada, "You're just like a bunch of Jesuits.'" Dallas leaned back in a reflective way and he said, "You're lucky. You've got a great band of Jesuits." I agree with him. We're here today to celebrate the excellence of 150 years of the Geological Survey of Canada. I'm particularly glad that those of you from "away", as they say in one part of this country, are here to celebrate with us.

In 1842 when William Edmond Logan was asked to "make a Geological Survey of the Province of Canada" it was probably a safe assumption that at that time the average citizen was not particularly well-informed of the need for geological knowledge to build a part of the economic base of a developing country. Now, 150 years later, perhaps citizens are generally better informed about these matters. But such awareness needs to be considered in a much more complicated context. The challenges today go far beyond the matter of assembling information

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on the mineral and fuel resource bases of the country. We are preoccupied with new questions as well. Questions that embrace such complex issues as sustainable development, threats against global ecosystems, perception such as climate change and major shifts in political and economic conditions that have taken place in many nations over the past few years. We now seem to be in a world that is changing so quickly that it threatens to outstrip our collective capacities to accommodate change.

We need to understand these changes and we have to find ways to solve the incredibly complex problems that arise from the impact of the human race on what seems to be an overstressed planet. More and more it becomes evident that an intelligent approach to these problems must rely on a solid foundation of knowledge about the processes and dynamics of the earth's natural systems. We need to understand how to sensibly balance economic development and the preservation of the natural environment. We need to worry about fresh water, undoubtedly the most precious of all our treasures. We need to tackle groundwater pollution, noxious emissions to the atmosphere, better prediction of earthquakes and better management of their effects. We need to develop systems to allow us to manage radioactive wastes forever. All of these phenomena have one thing in common. They do not recognize any political boundaries.

The knowledge we require has to be all-encompassing. It must embrace the systems of the oceans, the systems of the landmasses and the interface regions between the lithosphere and the biosphere. It needs to be global in span. Such a vast undertaking can only succeed through the collective and collaborative efforts of all of us.

It seems to us - and we would hope that many of you will agree - that to tackle the complicated issues before us we will need to rely more than ever before on the international institutions and organizations that permit scientists from all of our countries to work collectively towards common ends. Last night Dr. Price told us something about the role that geological surveys can play in these areas, and particularly about the requirements to have reliable information on which to base sensible policy formulation. To paraphrase Dr. Price, governments need effective information to govern effectively. It seems clear that these same information principles will apply equally to the larger requirements of the global community.

Cette conférence internationale des commissions géologiques a pour objectif de réunir les spécialistes du monde entier, et de faciliter les échanges sur les problèmes que je viens d'évoquer, et qui, en définitive, nous concernent tous. J'espère que cette conférence n'est qu'un début, et que d'autres suivront. Je suis certain que des idées utiles pour l'avenir sortiront des débats qui seront menés au cours de cette rencontre.

Pour conclure, j'aimerais vous rappeler que l'ouverture officielle des cérémonies du 150^{e} anniversaire de la Commission géologique aura lieu mardi après-midi, au siège de la CGC, sur la rue Booth. Nous nous réjouissons à l'idée de pouvoir vous y rencontrer en grand nombre, et vous êtes cordialement invités à y participer.

On a final note let me remind you that the official opening ceremonies for the Geological Survey's 150th Anniversary will take place Tuesday afternoon at the Survey's headquarters on Booth Street. It will be our pleasure to see as many of you there as possible.

I wish you on behalf of the Government of Canada the very best success in your deliberations over the next two days.

THEME I: EVOLUTION OF GEOLOGICAL SURVEYS (GEOLOGICAL SURVEYS IN TRANSITION)

A. National Geological Surveys

The Example of the British Geological Survey: past, present and future

P.J. Cook and P.M. Allen

The BRGM: Its structure and its role in the Earth Sciences in France and elsewhere

Z. Johan

B. State and Provincial Geological Surveys

State and Commonwealth geoscience agencies in Australia: their roles and functions

P. Playford

Role of Canada's provincial/territorial geological surveys circa 2000

W.D. McRitchie

State geological surveys of the United States of America: history and role in state government

A.A. Socolow and R.H. Fakundiny

Discussion

The Example of the British Geological Survey: Past, Present and Future

P.J. Cook[1] & P.M. Allen[2]

Cook, P.J. and Allen, P.M., The Example of the British Geological Survey: Past, Present and Future; in National Geological Surveys in the 21st Century, Bouchard, D.S et al. (compilers), Geological Survey of Canada, Bulletin 446, p.15-23, 1993

Abstract

The British Geological Survey was established in 1835 with a mandate geologically to map Britain. This example was followed by many other countries over the next 50 years. A pattern was established which saw the work of the geological surveys as an essential public service paid for and used by "the tax payer". This enabled most surveys to take a long-term strategic approach to geoscience. Mapping was (and indeed still is) seen as the primary role of the National Geological Survey and virtually all surveys had a programme, the aim of which was to complete the geological mapping of the country. Progressively, it was realised by the geologist that such an aim was neither achievable nor necessarily desirable. At the same time others questioned why areas were mapped, remapped and remapped again.

Recent technological developments have profoundly affected the type and quantity of data that surveys collect. However, the impact of technological change is perhaps even more profound in the areas of data manipulation and access to data. Now, the hard copy geological map is merely one option for data presentation. The fully digital geological map may be still "just around the corner", but already most surveys, including the British Geological Survey, have embarked upon a major digital map programme, the aim of which is to provide data in the form that customers want. This in essence means thematic maps "on demand" from digital databases presented either as hard copy maps or digital datasets.

Many changes in the way geological surveys work in recent years have resulted from changes in government philosophy, with many governments no longer prepared to leave it to surveys to decide what is in the "public good". In this context, most important in Britain was the introduction of the so-called Rothschild principle in 1973, which moved funding from the Survey to client departments which in turn then bought back those geological services from the Survey. The result of this was predictable enough with the system working well when times were good but producing a major downturn in the support for science in general, and geoscience in particular, when budgets of client departments became squeezed. Monetarist policies resulted in further changes as the user was expected to pay a progressively larger share of the cost. In Britain, it became obvious that the extension of this principle so that the user of a geological map was expected to bear directly a portion of the cost of the geological surveying would bring geological mapping to a halt. The first country to establish a geological survey came close to being the first country to abolish its survey! However, sense prevailed, the government was persuaded to maintain the British Geological Survey and

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increased the level of funding to enable it to commence a strategic programme of geological mapping to provide a uniform standard of geological mapping throughout Britain.

All of this has resulted in a British Geological Survey with a very different modus operandi to that of the original Survey or even the survey of 10 years ago. Much of the funding is now "soft"; long-term core funding constitutes less than 50% of the budget. This makes it difficult to develop a strategic approach in some areas. At the same time the Survey has survived and, indeed, started to prosper again after some difficult years. Traditional mapping activities now constitute a much smaller proportion of the Survey's activities and it is now necessary to have a balanced portfolio with a major involvement in activities related to waste disposal, groundwater resources studies, environmental geochemistry, et cetera, many of which are underpinned by geological mapping. The more monetarist approach has forced the Survey to strengthen marketing as an activity and vigorously to "sell" its services to the public and private sectors. To some this is an anathema for a geological survey, but if done in the right way can result in a significant gain to geoscience.

In the 1830's Britain served as an example to the rest of the world in establishing a national geological survey. The modern British Geological Survey may not necessarily serve as an example for the future for all countries but it is likely that as economic realities bite progressively more countries will be forced to follow its example.

Résumé

Le gouvernement britannique a créé sa commission géologique en 1835 et l'a chargée de la cartographie géologique du pays. De nombreux pays allaient faire de même dans les cinquante années qui ont suivi. Un modèle s'est établi: les travaux des commissions géologiques, estimait-on, constituaient un service essentiel, payé et utilisé par le contribuable. Cela a permis à la plupart des commissions géologiques d'aborder les sciences de la Terre dans une optique stratégique à long terme. On a considéré (et on le fait encore) que le rôle principal d'une commission géologique nationale est la cartographie, et presque toutes les commissions géologiques poursuivent un programme qui vise à faire la cartographie géologique complète du pays. Les géologues ont graduellement pris conscience du fait qu'un tel objectif n'était ni réalisable, ni nécessairement désirable. D'autres ont remis en question la cartographie fréquente de certaines régions.

Les récents progrès technologiques ont eu une profonde influence sur le type et la quantité de données que rassemblent les commissions géologiques, mais c'est peut-être dans les domaines de la manipulation des données et de l'accès aux données que l'on a ressenti le plus les effets des changements technologiques. Aujourd'hui, la carte géologique traditionnelle n'est qu'une option sur plusieurs pour la présentation des données. La carte numérique intégrale n'est peut-être pas encore pour demain, mais la plupart des commissions géologiques, dont la nôtre, poursuivent déjà de grands programmes de cartographie numérique, dont l'objectif est de fournir des données sous la forme qui convient le mieux aux clients. Cela veut dire, essentiellement, qu'on produira, à partir de bases de données numériques, des cartes thématiques «à la demande», sous forme de cartes traditionnelles ou de fichiers numériques.

À de nombreux égards, l'évolution du travail des commissions géologiques au cours des dernières années découle d'une réorientation de la pensée gouvernementale, et de nombreux gouvernements ne sont plus disposés à laisser les commissions géologiques décider de ce qui est dans l'intérêt public. Dans ce contexte, le changement le plus important à survenir chez nous a été l'adoption, en 1973, de ce que l'on a appelé le Principe Rothschild: une partie des crédits autrefois affectés à notre commission ont été transférés aux ministères clients, qui doivent à leur tour payer les services géologiques que nous leur offrons. Cela a eu des résultats prévisibles: le système fonctionne bien quand il y a assez d'argent, mais, quand les ministères clients subissent des compressions budgétaires, le financement des sciences en général et des sciences de la Terre en particulier connaît un recul marqué. Les politiques monétaristes ont entraîné d'autres changements, car on s'attendait qu'une partie de plus en plus grande des frais soit payée par l'utilisateur. Dans notre cas, l'application de ce principe voudrait dire que l'utilisateur d'une carte géologique doit assumer directement une partie des frais des levés géologiques. On s'est rendu compte que cela sonnerait le glas de la cartographie géologique en Grande-Bretagne. Le premier pays à créer une commission géologique a failli être aussi

le premier à la dissoudre! Fort heureusement, le bon sens a fini par l'emporter et le gouvernement a été amené à reconnaître qu'il fallait maintenir la British Geological Survey *et lui a affecté plus de crédits pour qu'elle puisse se lancer dans un programme stratégique de cartographie géologique visant à établir une norme uniforme de cartographie géologique pour l'ensemble du pays.*

Tout cela veut dire que notre mode opératoire a peu en commun avec celui de nos premiers jours ou même avec celui d'il y a dix ans. Une grande partie de notre financement est maintenant incertain. Le financement de base à long terme représente aujourd'hui moins de la moitié de notre budget. Il est donc difficile de planifier à long terme dans certains domaines. Malgré tout, la British Geological Survey *a échappé au pire et a même commencé à prospérer de nouveau après une période difficile. La cartographie traditionnelle constitue une bien plus petite part de nos activités et nous devons maintenant nous diversifier et jouer un rôle plus actif dans les secteurs de la gestion des déchets, de l'étude des eaux souterraines, de la géochimie appliquée à l'environnement, etc., où la cartographie géologique revêt souvent une grande importance. Le monétarisme du gouvernement a obligé la* British Geological Survey *à renforcer ses activités de commercialisation et à faire la promotion vigoureuse de ses services auprès des secteurs public et privé. Certains dénoncent cet état de choses, mais, à condition d'être appliquée judicieusement, cette formule peut beaucoup profiter aux sciences de la Terre.*

Dans les années 1830, la Grande-Bretagne a donné l'exemple au reste du monde en créant une commission géologique nationale. Aujourd'hui, notre commission ne servira pas nécessairement de modèle à tous les pays, mais il est probable que, face aux réalités économiques, d'autres pays devront suivre notre exemple.

INTRODUCTION

This paper will examine the manner in which the Geological Survey was established in Britain and how this served as an early role model for most of the world's major geological surveys. Over the years the British Geological Survey has changed in response to the changing needs of society, and scientific and technological advances. The rate of change has never been more marked than in the past 10 years.

This paper will examine those more recent changes, outline the nature of the British Geological Survey in 1992 and consider the extent to which the 1992 model of the British Geological Survey is likely to be applicable to other Geological Surveys now and in the future.

THE EARLY YEARS

The antecedents of the British Geological Survey lie perhaps first and foremost in the most active period of pioneering mapping of William Smith (Figure 1) extending from about 1790 to 1830. His work in southern Britain as part of the canal-building programme, which was underway at that time, resulted in the production of the first modern geological maps and in the formulation of the stratigraphic principles which underlie them. In 1791, Britain established the Ordnance Survey for the purpose of producing topographic maps of Britain at a scale of one inch to one mile. Flett (1937) reports that from the start, the Ordnance Survey was interested in incorporating geological information into their maps where possible and that several of the surveyors did have some geological knowledge (Flett, 1937). Indeed, Maclauchlan in southwest Wales and Still in southwest England put a considerable amount of effort into producing coloured geological maps. In 1832 the Ordnance Survey appointed its first full time geologist in Ireland. No similar appointment was made in England, although in 1831 Roderick Murchison lobbied for William Smith to be officially appointed as "Geological Colourer of Ordnance Maps". William Smith was 62 years of age at this time and was deemed to be too old for the job (he did, at least, finally receive official recognition for his services to geology in 1832 when he was awarded a government pension of £100 a year!) At about this same time Henry de la Beche was producing geological maps of western England including, for the first time, comprehensive maps of complete Ordnance Sheets, with a total of 8 sheets being produced in the period 1832–1835. Also at this time, the Geological Society of London was pressing for the setting-up of a Geological Survey and in responding to a request from the Master General and Board of Ordnance for an opinion on the feasibility of combining geological and geographical surveys, three members of the Society, Charles Lyell, William Buckland and John Playfair, placed particular stress on "The great advantages which must accrue from such an undertaking, not only as calculated to promote geological science which alone would be a sufficient objective, but also as a work of great practical utility, bearing on agriculture, mining, road-making, the formation of canals and railroads and other branches of national industry". (quoted by Bailey, 1952)

And so the scene was set for establishing a geological survey in 1835 initially as part of the Ordnance Survey, the first of many "parent bodies" for the Survey. Henry de la Beche (Figure 2) was appointed as its first Director, at the age of 39, with a clear mandate to address the practical aspects of geology. His success in pursuing this quickly became apparent, a particularly good example of this recognition is provided by no less an authority than Senor Sella, the Minister of Finance for the Kingdom of Italy (also a noted crystallographer and mathematician in his spare time) who in 1862 stated: 'England is without doubt the country where geological maps are prepared with much greater accuracy than in any other land. The singular importance of her mining industries, the spread of the elementary principles of geology, the zeal applied by the geologists charged with these labours, and the precision of the works, have been so accomplished that few undertakings of the British Government have so much contributed to the benefit of the public as the Geological Survey of the United Kingdom.' What wonderfully perceptive Ministers for Finance they had in those days! However, questions were being asked, notably how long would it take to complete the mapping of Britain? In his first attempt to respond to this question from the Secretary of the Treasury, de la Beche gave the ingenious answer (4 July 1835) "I consider that the Geological Map will keep pace with the Geographical Map and consequently that both Maps will be completed at the same time". This was not quite good enough for the Treasury and therefore in his further response of 9 July 1835, he is more specific stating "Estimating the rate of progress as above, Mr de la Beche considers that, assuming he receives the necessary aid, the Geological Map of England and Wales may be completed in about 10 years."

No doubt de la Beche came to regret his reply and certainly it is a question that has bedeviled directors of geological surveys ever since! It is also a matter to which we shall return. Despite these awkward questions, the Survey was highly successful; so successful in fact that it was quickly emulated by many countries including many British colonies, which in turn led to perhaps the earliest episode of geological head hunting.

Various members (or "volunteers") of the Survey became senior members of a range of colonial surveys including Murray (Director of the Newfoundland Geological Survey) Oldham (Director of the Geological Survey of India), Selwyn (Director of the Geological Survey of New South Wales) and Gould (Government Geologist to Tasmania).

One of the earliest of these emigrants was Logan. Through his work he developed considerable skills in geological mapping, first exhibiting his map of part of South Wales in 1837. "In 1840 Logan visited Canada and published several geological papers containing the results of his geological observations during his travels. In 1842 the Canadian Parliament decided to institute a Geological Survey and Logan was appointed geologist. De la Beche

Figure 1: William Smith

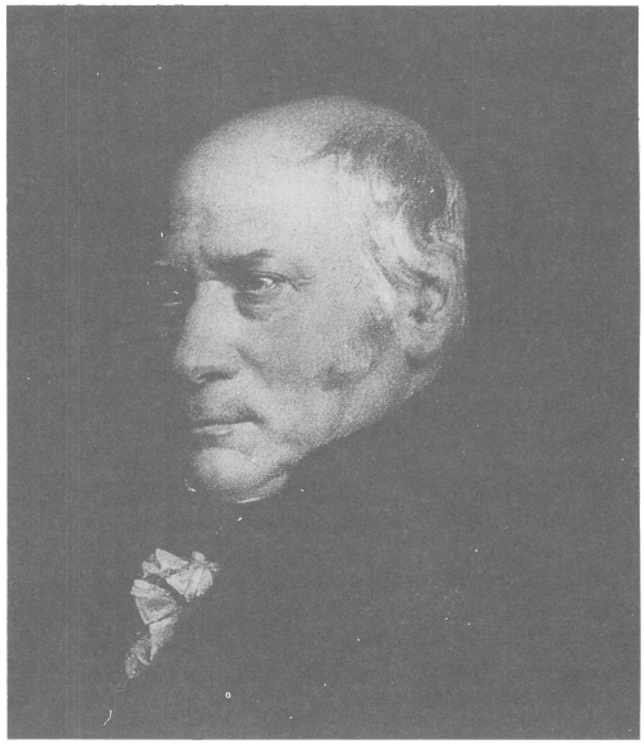

Figure 2: Henry de la Beche

wrote a letter supporting Logan's application and expressing in the highest terms his appreciation of the accuracy and thoroughness of Logan's work in South Wales" (Flett, 1937).

And so Logan became the first Director of the Geological Survey of Canada.

By the middle of the nineteenth century, the pattern of geological surveys throughout the world had been established: geological mapping was the primary function of all surveys but with a clear recognition that mapping was undertaken for a variety of practical reasons relating to mining, construction and transport. It became clear that geological mapping was not a short-term enterprise; it was a long-term and continuing undertaking. It was also recognized that good science was needed to underpin the primary role of geological mapping and that such mapping was not just a routine exercise in surveying but was a highly skilled interpretive exercise which also relied on skills such as palaeontology and mineralogy. The geological surveys expanded and also began to acquire a much wider range of skills. They began to look and act much more like the geological surveys of the twentieth century, and also were seen as essential to the material well-being of a country.

So, for more than a century, apart from periods of international conflict, the pace of change in the Geological Survey was measured and slow. The Survey continued to be structured for mapping, with the field staff being supported by a small number of palaeontologists, petrographers and chemists, who provided a service to them. Progressively, due to particular needs, Survey staff carried out a range of special investigations in support for the search for minerals, coal, oil, building stone and water but this was generally done either as an adjunct to the field survey, or within it.

In 1965, the Institute of Geological Sciences (IGS) was created by bringing together the Geological Survey and Museum of Practical Geology with the Overseas Geological Surveys in the newly formed Natural Environment Research Council. The effect of this union was dramatic. On the one hand, the Geological Survey was bound by its traditions, constrained in its vision by the scale of its mapping (six inches to the mile) and served by a narrow range of specialists. On the other, the Overseas Geological Survey (OGS) was a multidisciplinary support group, technically and scientifically modern in its approach, and structured to provide support for the Colonial Geological Surveys as well as supply them with their field staff, who worked at all scales from large to reconnaissance. With the OGS came photogeology, isotope geology, applied mineralogy, mineral intelligence, economics and statistics, modern chemical laboratories, new expertise in field geophysics and a new dynamic.

The broadening of the expertise base provided the platform for all subsequent developments. It allowed the IGS to widen its view of its strategic function and, in 1967, to enter major new fields such as marine geology and mineral resource evaluation.

Of all the influences that have been brought to bear by government on the evolution of the Geological Survey this century, three stand out as seminal. The first is the Report of the Machinery of Government Committee, (Viscount Haldane, 1918). The second is the report on "The organization and Management of Government R&D" (Lord Rothschild, 1971). The third cannot be linked to any internal enquiry of Government, but relates to an ideological shift towards the Market Economy during the 1980s.

The Haldane report of 1918 in the aftermath of World War I, recognised three classes of research legitimately carried out by Government: a) research done within Government Departments for their own purposes; b) research supervised by Departments, but which also met objectives shared by other Departments; c) research for general use, which had relevance to the workings of several Departments. Haldane insisted that the last category, which came to be called strategic research, must be developed to its fullest potential, saying, "Science ignores departmental as well as geographical boundaries," and warned about the dangers of departmental parochialism in research. It was Haldane's view that the Geological Survey carried out research of general use and in 1919, on his recommendation, the Geological Survey and Museum of Practical Geology was transferred from the Board of Education to the recently created Department of Scientific and Industrial Research. For more than half a century, the Geological Survey pursued a policy based on its acknowledged function to provide for national strategic aims.

It was already clear by the 1970s that Government was distancing itself from scientific research. In 1971 Rothschild reversed the 1918 Haldane report, for he was wholly committed to organising research on Departmental lines, funded directly by Departments through the customer/contractor relationship. The research was primarily meant to be applied. His concession to the need for some underpinning basic research was to suggest a 10% levy on contracts to cover it (which Departments, without exception, refused to pay). Strategic research, which Haldane thought so important, had gone from consideration for other government funding. Funding from the Science Budget was transferred to government departments with the expectation, though no formal condition, that it would be spent on research. The effect of this change on the Geological Survey was quite fundamental and after an initial increase in the budget there was then a progressive decrease and a consequent weakening of the Survey.

The emergence of free market economics in the 1980s following on Rothschild had a profound effect on the Geological Survey as one Department after another cut its support, sometimes at short notice. The Survey Director was urged to seek replacement funding from non-Government sources. The position of the Geological Survey as a national geoscience data centre, effectively the custodian of the nation's geological memory, was under severe threat as was its position as an impartial, independent agency, free to provide information to all enquirers.

Under the threat of extinction, the staff of BGS carried out an enquiry early in 1985 and developed the concepts of Core and Responsive programmes to describe the work of the Survey. In its original concept the Core consisted on the long-term, strategic activities without which the Survey would have no distinct identity. The Responsive programme, consisted of essentially applied research, done on commission, and largely short-term, often ad hoc in nature. The ability of the Survey to carry out this Responsive programme was dependent on the Core: thus the two were interdependent. There was considerable discussion about what should be put into the Core, with consensus agreement that it should comprise programmes of onshore, and offshore geological, geochemical and geophysical surveying, hydrogeological research and the maintenance of a national geoscience data centre.

In 1985, Sir Clifford Butler was commissioned by Government "to assess the UK need for geological surveying over the next 5-10 years...". His report, published in 1987, accepted the concepts of the Core and Responsive programmes, adding a third, Science programme in which underpinning basic research could be carried out. In addition, he recommended that the Core Programme should be overseen by a Programme Board made up of individuals from industry and academia with assessors from the Department of State. The Government accepted the recommendations of the Butler report and in November 1988 announced a special fund to support Core activities. This was important recognition by Government that there was a place for Government-funded strategic research. A second funding award, the next year, was made to allow the Survey to develop its capacity to exploit its data holdings and expertise in such a way as to earn money further to support the Core. In other words, the Survey was expected to pay for part of the Core Programme through its own commercial efforts.

In response to the requirement to increase our level of funding from Government and non-Government sources, the Survey has now been restructured at the divisional level along market sector lines (Figure 3). The Programme Divisions have particular responsibility for market sectors (corresponding in part to commodities) but at the same time the structure recognizes that mapping/surveying is an activity that is pursued by all the Programme Divisions. The Corporate Divisions tend to have fewer staff than the Programme Divisions and, as implied by the name, BGS-wide responsibilities. All Divisions are seen as business units with considerable

Figure 3: Restructuring along market sector lines

DIRECTOR							
PROGRAMMES DIVISIONS				CORPORATE DIVISIONS			
Thematic Maps & Onshore Surveys	Petroleum Geology, Geophysics & Offshore Surveys	Minerals & Geochemical Surveys	Groundwater & Geotechnical Surveys	International	Marketing	Corporate Coordination & Information	Administration

autonomy to determine how they will reach their agreed financial targets. Many services are now offered on a unit cost basis and there is a great deal of buying and selling of staff time between Divisions. Each year a Business Plan is produced which shows how targets will be achieved. One of the fundamental questions examined during reorganization was whether a commercial arm should be established separate from the Survey. It was decided that this should not be done because of the symbiotic relationship that exists between the core science and the contract work done for Government departments and the private sector. That makes for more complex management, but it ensures that neither activity becomes marginalized and high quality science, on which the reputation of BGS depends, is carried out across all activities. It is the view of the Survey that a more business-like approach is not only compatible with the management of good scientific research, but can in fact enhance it.

Through these new arrangements the core science funding is used to support a number of strategic programmes in mapping and monitoring. The largest single core activity is onshore geological mapping. A 15-year programme was started in 1990 with the aim of bringing the geological map of Britain to an acceptable modern standard, and making available 1:50,000 scale maps for the whole country. A schedule has been established for the publication of 300 maps sheets in this programme and mapping is proceeding apace. Full advantage is being taken of the increasingly sophisticated computer technology now available. BGS has developed a digital map production system for 1:10,000 standard maps, with the capacity potentially for proceeding directly to the 1:50,000 scale for publication. The system meets the requirement for printing full geological maps on demand and for the generation of special thematic maps from digital geological databases according to customer needs.

Apart from the flexibility in output that it allows, a digital system such as this allows periodic review and continual updating of maps and the publication of results cost effectively and fairly easily. Thus, as the mapping programme progresses, a programme of continuous revision of maps will take place in parallel for areas where there is a high level of construction activity, mineral extraction and oil exploration. The digital map production system is based on comprehensive and highly sophisticated digital databases which will be used to generate three-dimensional models. This is perhaps the most exciting new development. In the twenty first century, geological mapping in the highly populated parts of Britain may approach geological monitoring. However, the diverse and intense pressures that will be brought to bear on land for many often conflicting uses will require a highly sophisticated methodology for understanding the three-dimensional geology of the upper kilometre of the crust.

The extent to which other countries pursue the equivalent of a core mapping programme varies. Few, if any, base it on the 1:10,000 scale. For large countries such as Canada or Australia, it is impractical to aim for total national coverage at 1:10,000. Even 1:100,000 may be unrealistic and 1:250,000 commonly becomes the scale of choice for national cover. For many European countries a programme to provide full 1:10,000 coverage would be feasible, but few surveys are pursuing (or contemplating) such a programme of detailed mapping. This is in part a consequence of perceived national need and in part a consequence of tradition. Commonly, mapping is the preserve of the universities. The geologically exciting areas are mapped, and remapped in great detail, whilst other areas may be ignored. The value of having national cover of large-scale geological maps should be examined. It is perhaps significant that Britain, one of the most intensively geologically mapped countries in the world is also one of the world's major producers of raw materials. As resources become more difficult to find, as land use conflicts become more intense and as environmental concerns are heightened, so an increasing amount of detail will be required on the geological map. Therefore, it is likely that more European countries may find it necessary to follow the UK's lead and develop systematic national large-scale mapping programmes, and that they will employ digital methods for geological database building and map generation. The rigour that this will impose may result in a trans-national approach to mapping, something which is long overdue in Europe.

Whilst onshore geological mapping is the major part of the BGS core science programme, it is not the only part. Nearly all the British continental shelf has been mapped and offshore mapping remains part of the core programme. Science Budget funds are used both for individual projects and, increasingly, as "seed money" which together with industry support can be used for large mapping projects. One such example is to map the Rockall trough, a relatively unknown part of the UK continental margin.

A major core programme on regional geochemical surveys has been underway for twenty-three years and more than half of Britain has been geochemically mapped. While the initial impetus for this programme was to support the search for mineral deposits, increasingly it has become relevant to questions regarding industrial pollution, land use and human and animal health. This programme involves detailed sampling of stream bed sediments, water and pan concentrates at an approximate spacing of one sample per square km. A total of 35 elements are analyzed for each stream sediment sample, five determinations are also made on every water sample with twenty additional analytical values recently added to the suite. Water samples are now collected at the same density as stream sediment samples. Heavy mineral concentrate samples are collected, visually examined and analysed by non-destructive methods where they have potential to aid mineral exploration. Similar, but generally less comprehensive programmes are underway in many countries; for example Canada. In Europe there have been discussions on a multi-nation approach to geochemistry for a number of years but as yet there is no agreement on the methodology. Indications so far are that the British regional geochemical survey programme is fulfilling its planned purpose and may be a useful model for other countries to follow. In the absence of similar types of survey in other counties we are likely to see regional geochemistry, albeit severely limited in scope, being done by remotely sensed methods, particularly radiometrically. This is an area where Britain does not have a viable programme.

The core Science Budget supports only a very limited amount of hydrogeological and geotechnical mapping in Britain. The absence of a national mapping programme in either field is a major deficiency of the core programme and one which we hope to address in the future.

Geophysics is carried out within the core programme in two parts. Geophysical surveys and interpretations are done in conjunction with the core mapping programmes, while geomagnetic and seismic monitoring programmes are free-standing. Both the land area and continental shelf are covered by modern gravity surveys; on land at better than one station per 2 km^2. Aeromagnetic survey data, however, dates from the 1960s onshore and more recently offshore. All the potential field data have been digitized and have yet to be fully interpreted, but the limitations of the aeromagnetic data are now known and the need for national cover of high resolution aeromagnetic and VLF or EM surveys is recognised. So far, attempts to raise funds to carry them out have failed. Seismic and magnetic monitoring are funded only in part through the core programme. It can be argued that programmes on seismic hazards should be funded entirely by the national government because of its relevance to the whole community. This is not a view shared by the UK government and increasingly this and geomagnetic monitoring are being funded through industry/government consortia. Under this arrangement a long term strategic programme can be pursued, but at the same time a number of products, tailored to the needs of the members of the consortia are also provided.

Both the core and responsive programmes depend heavily on ready access to comprehensive databases. In a recent survey of BGS dataholdings, 774 databases were identified, of which 265 were digital. Work is presently underway to establish a data architecture that will establish linkages between a large number of these data sets, thus making them more accessible and more usable. Special government funding was provided to help this process. The benefits to the Survey of this investment are two fold: (1) Enhancement of the Survey's programmes (both core and contract) (2) Enhanced public access to the databases. Together, these have the effect of making the core programme more cost effective and bringing in additional income from contracts and data sales (or licensing) in order to enhance the core science. The BGS has a strategic plan for achieving these aims; effective data architecture and the appropriate hardware configurations are an essential part of that plan. It is anticipated that the system will be in place within 18 months.

One of the fundamental issues regarding a data service is whether it should be provided for the public good at little or no cost or whether it should be provided at full cost recovery. This is essentially a political question and, for the present, the UK government has taken the view that BGS should aim for full cost recovery for data and services; the charge should reflect the value of the service or the data to the user, although no attempt is made to cover the cost of data collection, or survey. A change in this philosophy would not cause any profound problems for BGS - provided the loss of income from these activities is made up from government sources.

The British Geological Survey served as a very important example in the nineteenth century. It is responsible for the "traditional" approach of many of the world's major surveys, such as the importance placed on geological mapping, the value of multidisciplinary geoscience, the need for a long term strategic approach to many studies and the public funding of those activities. Not surprisingly, the BGS has changed quite drastically during its more than 150 years of existence but the rate of change has been most marked in recent years. Many of the basic tenets have been questioned by those outside the Survey and the view that the Survey knows best what it should be doing is no longer an acceptable dogma. "The customer", whether in the private or the public sector, is now the arbiter of what is required from a survey and either we adapt or we wither on the vine. Contract science, whether we like it or not, has come to dominate our programme in such a way that if we lost it, it is unlikely that any government would provide public funds to make up for any loss of funds from the private sector. It has also to be acknowledged that contract science has brought with it the discipline of a business-like approach and the need for quality assurance and quality control. However, perhaps the greatest loss would result from the breaking of the strong links that have developed between customers and the Survey leading not only to a loss of data exchange but also a potential loss of relevance and the stimulation of that relevance.

The preferred future course for the BGS requires the establishment of the right balance of core and contract science. Just where that balance lies will vary with time as government and community priorities change. The Survey must continue to ensure that it is able to respond to these changes.

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The BRGM: Its Structure and its Role in the Earth Sciences in France and Elsewhere

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Abstract

The BRGM (Bureau de Recherches Géologiques et Minières) was created in 1959 to combine the various geological organizations which had formed after World WarII and which had operated both in metropolitan France and in its overseas territories. Its status is that of an EPIC (Établissement public à caractère industriel et commercial), or public establishment of an industrial and commercial nature. In 1961, the BRGM repatriated the geological mapping service of Guiana, and in 1967 merged with the French mapping service (Service de la Carte de France, created in 1868). This consolidation has led to a large increase in geological mapping activities and basic geological research. The creation in 1965 of a scientific and technical centre in Orléans made it possible to concentrate the main resources in a single location and to develop a structure for co-ordinating activities in France and abroad.

In 1990, BRGM personnel numbered 1544 officers, of which 954 were senior staff. The BRGM is organized around three operational branches, comprising the national geological service, soil and subsoil services and mining activities; and two strategic support branches - the scientific branch and the development branch. This structure allows it to develop activities according to three approaches: as a public service within the national geological service; as a service corporation acting in the competitive sector; and as the parent corporation of an international mining group.

The BRGM has activities in the following fields: geological surveys of the land base; exploration and development of mineral resources; management of ground water; protection of the environment; and subsoil studies related to civil engineering projects.

The annual budget for scientific research allocated by the government to the BRGM is about 200million francs (23% of the total budget), including funds from the EEC. The scientific management of the BRGM is responsible for research programming, management of the resources allocated and follow-up and evaluation of the results of research projects. It has several evaluation structures to which are associated the researchers from the outside agencies. The BRGM is an important centre for training through research: about fifty students are preparing their doctoral theses here, most of whom receive BRGM scholarships.

The BRGM does not have a corps of researchers. Provided there is enough uninterrupted time spent on scientific projects, this type of structure benefits the continuous training of researchers and favours the downstream transfer of the results, but it does assume a particularly effective evaluation system.

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The research program is structured around the following main themes: (1)environment; (2)-geological mapping of the national land base; (3)management and protection of ground-water resources; and (4)metallogeny, exploration and raw materials beneficiation. In the environmental field, the emphasis is on processes of pollutant transfer between the unsaturated zone and the water table, natural hazards (seismic, volcanic, land movements) and waste storage (including nuclear waste). Multicriteria mapping is one of the priority objectives. Two scientific projects in support of the surveys are in progress (the north Breton Cadomien and the Velay zone in the French Massif Central). The BRGM is responsible for managing the national program on the "deep crustal geology of France". In addition to understanding and modelling phenomena occurring in the saturated and unsaturated zones, the various aspects relating to the management and quality of ground-water resources are dealt with. The BRGM is co-piloting a major European project on the "hot dry rocks" of Soultz-sous-Forêts. In the area of metallogeny and mineral exploration, research is focused on an understanding of the mechanisms by which metallic elements are concentrated, essential for the development of new exploration methods. In mineral processing, efforts are aimed at process computerization, bioprocessing of refractory minerals and optimization of industrial mineral properties. A new project on "environmental mineral processing" will be initiated.

In addition to the EEC countries, the BRGM is developing relations in scientific collaboration with similar agencies in most of the industrialized countries. Many co-operation agreements attest to this. A recent important opening toward the countries of Central and Eastern Europe is developing.

Résumé

Le BRGM (Bureau de recherches géologiques et minières) a été créé en 1959 pour regrouper les différents organismes géologiques qui avaient vu le jour après la seconde guerre mondiale et qui opéraient tant en France métropolitaine que dans ses territoires d'Outre-Mer. Son statut est celui d'un établissement public à caractère industriel et commercial (EPIC). En 1961, le BRGM reprend le Service de la carte géologique de Guyane est c'est en 1967 que le Service de la carte de France (créé en 1868) fusionne avec le BRGM. Ce regroupement entraîne une forte croissance des activités de cartographie géologique et des recherches dans le domaine de la géologie fondamentale. La création, en 1965, d'un Centre scientifique et technique à Orléans a permis de concentrer l'essentiel des moyens en un seul site et de développer une structure de coordination des activités en France et à l'étranger.

En 1990, les effectifs du BRGM étaient de 1 544 agents, dont 954 cadres. Le BRGM est organisé autour de trois directions opérationnelles : Service géologique national, Services sol et sous-sol, Activités minières, et de deux directions d'appui stratégique : Direction scientifique et Direction du développement. Cette structure permet de développer les activités suivant trois modalités : service public au sein du Service géologique national ; société de services agissant dans le secteur concurrentiel; société-mère d'un groupe minier international.

Le BRGM intervient dans les domaines suivants : la connaissance géologique des territoires; l'exploration et exploitation des ressources minérales; la gestion des eaux souterraines; a protection de l'environnement; les études du sous-sol relatives aux projets de génie civil.

Le budget annuel de la recherche scientifique alloué par les pouvoirs publics au BRGM s'élève à 200 millions de francs environ (23 % du budget total) y compris les crédits venant de la C.E.E. La Direction scientifique du BRGM est chargée de : la programmation de la recherche, la gestion des moyens alloués, le suivi et l'évaluation des résultats des projets de recherche. Elle dispose de plusieurs structures d'évaluation auxquelles sont associés les chercheurs des organismes extérieurs. Le BRGM est un important centre de formation par la recherche : une cinquantaine d'étudiants y élaborent leurs thèses de doctorat, dont la plupart bénéficient d'une bourse du BRGM.

Le BRGM ne dispose pas d'un corps de chercheurs. Ce type de structure, à condition que le temps consacré au projets scientifiques soit suffisamment continu, est bénéfique à la formation permanente des chercheurs et favorise le transfert des résultats vers l'aval, mais il implique un système d'évaluation particulièrement efficace.

Le programme de recherche est structure autour des axes principaux suivants : 1. Environnement ; 2. Cartographie et connaissance géologique du territoire national ; 3. Gestion et protection des ressources en eaux souterraines ; 4. Métallogénie, exploration et valorisation des matières premières. Dans le domaine de l'environnement, l'accent est mis sur les processus de transfert des polluants entre la zone non saturée et les nappes d'eau souterraine, les risques naturels (sismiques, volcaniques, mouvements de terrain) et le stockage des déchets (y compris des déchets nucléaires). La cartographie multicritères constitue l'un des objectifs prioritaires. Deux projets scientifiques d'appui aux levés sont en cours (Cadomien nord-breton et zone du Velay dans le Massif Central français). Le BRGM est chargé de la gestion du programme national «Géologie profonde de la France». Outre la compréhension et la modélisation des phénomènes survenant dans la zone saturée et non saturée, les différents aspects concernant la gestion et la qualité des ressources en eaux souterraines sont traités. Le BRGM co-pilote un grand projet européen «roches chaudes sèches» de Soultz-sous-Forêts. Dans le domaine de la métallogénie et de l'exploration minière, les recherches sont focalisées sur la compréhension des mécanismes de concentration d'éléments métalliques qui est essentielle pour le développement de nouvelles méthodes d'exploration. En minéralurgie, l'effort est consacré à : informatisation des procédés ; bio-traîtements des minerais réfractaires ; optimisation des propriétés des minéraux industriels. Un nouveau projet, intitulé «Minéralurgie de l'environnement» sera lancé.

Outre les pays de la CEE, le BRGM développe une collaboration scientifique avec les organismes analogues de la plupart des pays industrialisés. De nombreux accords de coopération en témoignent. Récemment, une ouverture importante s'effectue vers les pays de l'Europe centrale et orientale.

BACKGROUND

The BRGM (Bureau de Recherches Géologiques et Minières) was created by ministerial order on October 23, 1959 to combine in a single structure four geological organizations of differing status which, except for the BRGGM (formed in 1941), were established in the years following World WarII.

These organizations were:

- the Bureau Minier de la France d'Outre-Mer (BUMIFOM);
- the Bureau de Recherches Minières de l'Algérie (BRMA);
- the Bureau Minier Guyanais (BMG); and
- the Bureau de Recherches Géologiques, Géophysiques et Minières de la France Métropolitaine(BRGGM).

In 1961, the BRGM repatriated the operations and staff of the geological mapping service of Guiana. Finally, the Service de la Carte Géologique de France, created in 1868 as an overseas service of the mines branch, merged with the BRGM on January 1, 1968, its hundredth birthday. This amalgamation would lead to a major increase in basic geological studies and scientific research, and would open the BRGM to the French university community (G. Sustrac, 1986).

The consolidation in Orléans beginning in 1965 was essential to the progress of the BRGM. It made possible the creation of a scientific and technical centre which, with the support of the French department of research at the time, was equipped with the most modern research tools available, and allowed the establishment of a structure for the general co-ordination of all BRGM activities in France and abroad (PhBourrelier, 1984).

The BRGM is organized around three operational branches, the national geological service, the soil and subsoil services and mining activities, and two strategic support branches, the science branch and the development branch.

The principle of major scientific research at the BRGM is closely linked to the functions assigned to it at the time of its creation. This research mission quickly led to many contacts with the National centre for scientific research (CNRS), several laboratories of which have also been established in Orléans, next to the BRGM and, quite naturally, in conjunction with the University of Orléans as well.

Accordingly, with the aim of structuring research in the field of metallogeny, a research group (the GDR) was created in 1977 involving the Centre de Recherches sur la Synthèse et la Chimie des Minéraux (CNRS), the University of Orléans and the BRGM. Since then, this group has earned a solid international reputation in the metallogeny of basic and ultrabasic rocks and in the study of mineralizing processes related to the evolution of granitoids.

In the same spirit of collaboration, a number of large installations have been set up as part of common laboratories.

With the Agence Française sur la Maîtrise de l'Énergie (AFME), the BRGM has created a joint institute for geothermal research (IMRG), the hub of scientific geothermal research in France.

In 1982, a Mission Générale de Coordination Scientifique was established at the BRGM. At the request of the Minister for research and technology, this was transformed in 1985 into a science branch. This creation has considerably strengthened the programming and evaluation of research at the BRGM.

SCIENTIFIC RESEARCH AT THE BRGM

Structure of programming and evaluation

The orientation of an applied research program is the domain of the financial backer, and is determined as a function of its ultimate goals and concerns and the ideas of the research teams. Scientific research at the BRGM must have its primary justification in the development of earth science activities by French companies, and in greater understanding of the subsurface geology of France. As it is also a service undertaking and a mining investor, the BRGM is potentially a major beneficiary of its own research work. However, a totally self-serving role must be avoided and active attention must be paid to the needs of economic sectors that depend on the earth sciences.

Scientific research financed by public funds from the department of research and space, with complementary funding mostly from the EEC, is only one of the missions given to the BRGM. In fact, in addition to the role the BRGM plays as an earth science research centre, the government has assigned it missions of service to the public, of exploration and of mine development.

In 1991, scientific research accounted for 22% of total activity at the BRGM, while service activities represented 57%. The budget allocated to research in 1992 is 208.5 million FF. These figures show that scientific research at the BRGM receives a small proportion of the budget, even though the Bureau includes the Service Géologique National. Because its activities are diversified, the BRGM does not have a specific corps of researchers, and officers can be asked to devote only part of their time to the research effort. This situation requires good control in programming and evaluating scientific research – the primary, constant concern of the BRGM's scientific administration.

Two research orientation and evaluation structures have been set up:

1. The "Comité des Sciences de la Terre", attached to the BRGM board of directors, advises on changes in needs and methods in geology, the environment and control of subsurface resources, and monitors the preparation of scientific research and public service programs. Its 33 members, appointed by ministerial order, represent the scientific community (21 members) and the industrial community (12 members). A number of representatives from research agencies and industry in EEC member countries sit on this committee.

2. The "Comités d'orientation et d'évaluation sectoriels" (CORES), of which there are three, are chaired by well-known scientists from outside the BRGM. These CORES deal with the following areas: (i)basic geological knowledge; (ii)water - environment - land use planning; and (iii)mineral resources. The committees give their advice on the quality of research projects and the results obtained.

It was decided in 1990 that research projects would be handled on a contractual basis; projects are covered by a contract between the science branch and the project manager. In addition, each contract is co-signed by the project manager's direct line supervisor. Contracting has become a necessity because most projects are multidisciplinary and require researchers or teams located in the various operational branches of the BRGM. Thus scientific research acts as a "cement" that binds the BRGM units together. However, care must be taken that contracting does not hinder the emergence of new ideas – it must not encroach upon scientific creativity.

To ensure that BRGM research scientists receive the full recognition their careers deserve, evaluation criteria have been defined. Two evaluation levels are considered:

(i) evaluation of the intrinsic quality of research projects, their impact on the BRGM's scientific strategy and their impact outside the BRGM;

(ii) evaluation of researchers from the standpoint of multiple-criteria development comprising publications, papers at conferences, symposia and seminars, and theses, as well as the ability to lead a research team and the ability to open communications outside the BRGM nationally and/or internationally.

Orientation of scientific research at the BRGM

The research program is structured around the following main themes (the percentage of the 1992 budget allocation is given in parentheses):

1. Environment, management and protection of ground water resources, geothermal energy, natural hazards (32.4%);.

2. Geological mapping and information on the geology of France (34.2%);.

3. Metallogeny, exploitation and beneficiation of raw materials (19.6%);

4. Basic tools and methods (mineralogy, petrology, analyses, geophysics and geological data processing) (13.8%).

These themes correspond to the BRGM areas of excellence which the science branch is committed to promoting and developing.

In addition, the BRGM benefits from two specifically reserved budgetary appropriations of national interest:

- the national program on the "Géologie profonde de la France";
- "Recherches en Partenariat Industriel", in response to the needs expressed by industry, bringing together BRGM researchers and representatives from industrial corporations around a research topic.

It should be pointed out that the BRGM is an important research training centre. In fact, about fifty students are preparing their theses at the Bureau and the BRGM awards approximately fifteen thesis scholarships each year.

MAIN RESEARCH SUBJECTS

This article cannot mention all the research projects currently under way at the BRGM. Only the projects marking the major research themes will be briefly described.

Environment, ground water, hazards, geothermal energy

In the environmental field, the emphasis is on diffuse pollutants of soil and ground water, including both the problem of the migration of organic micropollutants in aquifers and studies on the mobility of heavy metals in soil and water. This research is strongly supported by the EEC.

The accumulation of waste materials is also an important theme, oriented toward the behaviour of waste in relation to water and the development of tools for monitoring confining structures. A number of research projects are investigating phenomena of water/rock interaction, the study of which is directly applicable to both the modelling of pollutant plumes around storage structures for industrial and urban waste and to the circulation of fluids at sites selected for storing nuclear waste.

Research is continuing on purification methods. For example, treatment of water by geo-purification has been approached, as has the on-site technique for biodegrading hydrocarbons where ground water has been polluted. The results of these experiments are particularly promising.

In the area of natural hazards, the emphasis is on the following sub-themes: the regional earthquake hazard and reduction of the earthquake threat in a large city with low seismicity (Nice); improved understanding of the various types of volcanic eruption mechanisms and its application to the methodology of monitoring and metrology; and prevention of hazards generated by earth movements.
Special attention is being paid to the study of fractured rock environments, particularly their hydromechanical behaviour. In fact, this research is of fundamental importance both for the development of gèothermal heat exchangers of the "hot dry rocks" type and for the circulation of fluids around nuclear waste storage sites.

In the field of management and protection of ground water resources, the research projects are aimed at understanding and modelling basic phenomena occurring in the unsaturated and saturated zones, and at the different aspects of water resource management. The research is strongly oriented toward computer developments concerned with modelling the hydrodynamics and hydrochemistry of aquifers and the establishment of an interactive system to assist in making water management decisions.

The research on geothermal energy is focusing on the large European "hot dry rocks" project of Soultz-sous-Forêts, the purpose of which is to set up a pilot study for the prototype of an underground heat exchanger in granitic basement rock. This project involves the participation of many German, British and French teams. The use of the geothermal resources of the Dogger in the Paris basin has come up against problems related to corrosion of the installations. An understanding of the corrosion/deposits processes in geothermal two-well systems should benefit from the knowledge obtained in projects on the water/rock interaction mentioned above.

Geological mapping and information on the geology of France

In 1992, nearly 90% of metropolitan France will be covered by geological map sheets on a scale of 1:50,000. Control of survey quality is the responsibility of the Comité de la Carte Géologique de France. A new edition of the geological map of France at 1:1,000,000 is currently under way. Geological mapping in the future is one of the priority objectives of the research project on multiple-criteria mapping. Substantial backing is being given to the two scientific projects in support of the surveys, which involve, in addition to the BRGM researchers, a number of university teams and the CNRS. These undertakings are the "north Breton Cadomien" project, aimed at a geodynamic understanding of that segment of the Cadomien chain, and the "Le Velay" project, the objective of which is an understanding of the intrusion of a vast migmatitic dome late in the Hercynian orogeny.

The national program on the "subsurface geology of France" is working on its fourth target, the Balazuc site, where the research program is oriented toward modelling the circulation of fluids in the context of a spreading paleomargin.

Metallogeny, exploitation and beneficiation of raw materials

Historically, the earth sciences in Orléans have been strongly oriented toward metallogeny and the beneficiation of ores. The research projects focus on an understanding of the mechanisms of metallic element concentration in magmatic and hydrothermal systems, essential for the development of new exploration methods. More recently, the emphasis has been on the metallogeny of gold, but there has just been a diversification of subject matter in the direction of base metal deposits (Pb-Zn-Cu). Thus major research projects supported by the EEC, involving Pb-Zn mineralization of overburden and sulphide masses, were begun in 1990 and are continuing.

High-technology metals are the subject of projects on mineralization by rare earths and on platinum group deposits highly enriched in Pt and Rh. These projects are being developed as part of an international co-operative effort with a number of countries having high mineral potential (Gabon, Australia, Madagascar and Albania).

Geochemical prospecting continues to focus on the processes of dispersion of metals in a tropical environment, but the interpretation of leak anomalies, particularly those associated with sulphide masses, is becoming an important objective.

In the area of mineralogy, the following themes are being dealt with: column flotation, bioprocessing of refractory sulphide ores, optimization of industrial mineral fillers and computerization of processes for treating mineral raw materials.

Basic tools and methods

The emphasis is on geochemical tools applied to paleoclimatology and, more broadly, to geological predictions. In addition, analytical methods, both isotopic and involving quantitative trace element determination, are a stated priority in their application to hydrogeochemistry and to the geochemistry of soils and rocks.

FUTURE PROJECTS

The environment is a priority field for coming years. To meet many expressed needs in protecting and rehabilitating water resources, as well as the soil and subsoil, an integrated study will be done on the processes by which pollutants are transferred from the unsaturated zone to the saturated zone. This research will include laboratory studies, field studies and model pairs to develop methods and tools for protection, rehabilitation and management.

Such an approach requires good control of metrology, both in the laboratory and in the field; this involves development of a co-ordinated policy of well-instrumented experimental sites allowing work to be done on a short-term or long-term basis, as applicable. An understanding of the processes characteristic of the unsaturated zone will be based on the study of interactions between fluids and minerals and on the processes by which mineral and organic micropollutants are trapped.

Special attention will be given to problems related to the mining environment. We hope this research subject will be developed across Europe. The use of mineral processing methods for the treatment of industrial waste is also a major possibility, particularly in the present economic situation.

In the field of geological mapping, research will be continued on new ways of formatting available geological information to meet the needs of users. Research will be stepped up in particularly important areas, such as fracturing in the rock structure and its permeability to fluids, the interaction between fluids and minerals and approaches that will lead to the concept of geological predictions.

The need to modernize mineral exploration equipment prompts us to give special attention to the method of exploring deep, hidden deposits; gas and ultratrace geochemistry will play an important part in this.

A new avenue is being opened up. It involves research on geomaterials for which uses can be broadened and new industrial applications proposed.

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State and Commonwealth Geoscience Agencies in Australia: Their Roles and Functions

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Abstract

Geological Surveys were established in each of the Australian colonies during the second half of the nineteenth century -- Victoria (1852), Queensland (1868), New South Wales (1875), South Australia (1882), Tasmania (1883), and Western Australia (1888). Federation of the colonies to form the Commonwealth of Australia in 1901 did not result in the establishment of a national geological survey. Under terms of the Australian Constitution, mineral rights remained with the states, and consequently geological survey work was seen as a state rather than Commonwealth responsibility. However, it was decided after World War II that there was a need for a national organization to facilitate geological mapping of the continent and to advise the Commonwealth Government on earth-resources issues. Consequently the Commonwealth Bureau of Mineral Resources, Geology and Geophysics (BMR) was established in 1946, and since then has functioned essentially as a national geological survey. The last geological survey to be established in Australia was that of the Northern Territory, in 1970.

The primary role of each state/territory geological survey is to record and interpret the geology of its state or territory, to provide the results to government, industry, and the general public, and to advise on relevant environmental, land-use, and resource issues. Geoscientific research by the surveys is primarily field based, concentrating especially on geological mapping. They also conduct detailed research in fields such as structural geology, petrology, the regolith, geochemistry, hydrogeology, basin analysis, environmental geology, metallogeny, geomechanics, geochronology, paleontology, geophysics, and geoscientific computer applications, including database development.

The Bureau of Mineral Resources (BMR) functions as the advisor to the Commonwealth Government, industry, and the general public on the geology of the continent, and on various environment, land-use, and resources issues of national interest. It is also responsible for geoscientific work in Australia's Antarctic Territory and various island territories. The BMR has a greater role than the geological surveys in relation to offshore geology, as the Commonwealth has constitutional jurisdiction over Australia's offshore areas. However, day-to-day administration of offshore minerals and petroleum has been delegated through legislation to the respective state and territory governments.

The BMR's research is largely field oriented, and mapping is carried out in close cooperation with the geological surveys, through the National Geoscience Mapping Accord, coordinated by the annual Chief Government Geologists' Conference. Under the terms of this Accord, an agreed program to produce a new generation of geological maps of the continent is being shared by the BMR and geological surveys.

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The BMR also conducts detailed research in the categories listed above for the geological surveys, focusing on areas of national importance. However, unlike most surveys, the Bureau is also responsible for rextensive geophysical data acquisition and processing, especially through seismic and airborne geophysical surveys. In addition, the BMR has primary responsibility for earthquake and geomagnetic monitoring and research throughout Australia.

The other federal agency with responsibilities in geoscience is the Commonwealth Scientific and Industrial Research Organization (CSIRO), which first became involved in minerals research in 1926. CSIRO's principal geoscientific research is now carried out in four divisions: The Division of Exploration Geoscience, which seeks to develop improved geological, geophysical, and remote-sensing methods for mineral and petroleum exploration; the Division of Geomechanics, which undertakes geotechnical studies associated with mining, petroleum development, and engineering construction; the Division of Water Resources, which is responsible for hydrogeological research; and the Division of Soils, which undertakes geological, geotechnical, and pedological research.

There is a general consensus in Australia that geological mapping and geoscience data handling are the most important functions of geological surveys and the BMR from the point of view of the mining and petroleum industries. However, none of these agencies are now providing adequate levels of service, especially with regard to mapping, because of the lack of sufficient resources. Consequently the ambitious National Geoscience Mapping Accord is falling well behind schedule. Indeed, in most surveys there has been a substantial decline in mapping over the past 15-20 years, associated with falling levels of funding and staffing. If this trend is not reversed, it is likely to have long-term adverse effects on the nation's largest industry, mining, and on environmental management and land-use planning.

Résumé

Des commissions géologiques ont été créées dans chacune des colonies australiennes pendant la deuxième moitié du XIX^e^ siècle: Victoria en 1852, Queensland en 1868, Nouvelle-Galles-du-Sud en 1875, Australie-Méridionale en 1882, Tasmanie en 1883 et Australie-Occidentale en 1888. La confédération des colonies en Commonwealth d'Australie en 1901 n'a pas mené à la constitution d'une commission géologique nationale. Aux termes de la constitution australienne, les droits miniers appartiennent aux états et les levés géologiques sont donc considérés relever des états plutôt que du Commonwealth. Au lendemain de la deuxième guerre mondiale, il fut toutefois décidé qu'il fallait avoir une organisation nationale pour faciliter la cartographie géologique et donner au gouvernement national des conseils en matière de ressources terrestres. C'est ainsi que fut établi, en 1946, le Bureau of Mineral Resources, Geology and Geophysics (BMR), qui, depuis, fonctionne essentiellement comme commission géologique nationale. La dernière commission géologique à être créée en Australie a été celle du Territoire-du-Nord, qui a été établie en 1970.

Le principal rôle de ces commissions géologiques est de recenser et d'interpréter la géologie de l'état ou du territoire, de fournir les résultats de ces travaux au gouvernement, au secteur privé et au public, et de donner des conseils à propos de questions connexes dans les domaines de l'environnement, de l'occupation des sols et des ressources. Les recherches géoscientifiques qu'elles effectuent consistent surtout en travaux sur le terrain et notamment en travaux de cartographie géologique. Elles poursuivent également des recherches approfondies dans des domaines comme la géologie structurale, la pétrologie, le régolite, la géochimie, l'hydrogéologie, la paléogéographie, la géologie de l'environnement, la métallogénie, la géomécanique, la géochronologie, la paléontologie, la géophysique et les applications géoscientifiques de l'informatique, notamment la constitution de bases de données.

Le Bureau of Mineral Resources, Geology and Geophysics (BMR) conseille le gouvernement national, le secteur privé et le public en matière de géologie du continent et à propos de diverses questions d'intérêt national concernant l'environnement, l'occupation des sols et les ressources. Il est également responsable des travaux géoscientifiques dans le territoire antarctique et divers territoires insulaires de l'Australie. Il joue un plus grand rôle que les commissions géologiques dans le domaine de la géologie marine, étant donné que les zones extracôtières de l'Australie relèvent du gouvernement

national en vertu de la Constitution. Toutefois, l'administration courante des ressources minérales et pétrolières extracôtières a été déléguée par voie de législation aux divers états et territoires.

Les recherches du BMR sont surtout axées sur les travaux sur le terrain, et la cartographie est effectuée en étroite collaboration avec les commissions géologiques, dans le cadre du National Geoscience Mapping Accord, *coordonné aux congrès annuels des géologues en chef des administrations. Aux termes de cet accord, le BMR et les commissions géologiques collaborent à un programme qui vise à produire une nouvelle génération de cartes géologiques du continent.*

Le BMR effectue également des recherches approfondies dans les domaines dont s'occupent les commissions géologiques, mais se concentre sur les secteurs d'importance nationale. Toutefois, contrairement à la plupart des commissions géologiques, le Bureau est également responsable d'un vaste programme d'acquisition et de traitement de données géophysiques, qui comprend notamment la réalisation de levés sismiques et de levés géophysiques aéroportés. En outre, le BMR a la principale responsabilité de la surveillance et de la recherche sismiques et géomagnétiques dans toute l'Australie.

L'autre organisme fédéral qui a des responsabilités dans le domaine des sciences de la Terre est la Commonwealth Scientific and Industrial Research Organization *(CSIRO), qui a commencé à faire des recherches sur les ressources minérales en 1926. Les principales recherches géoscientifiques de la CSIRO sont maintenant effectuées dans quatre divisions: la division de la géologie d'exploration, qui cherche de meilleures méthodes géologiques, géophysiques et de télédétection pour l'exploration minière et pétrolière; la division de la géomécanique, qui effectue des études géotechniques dans les domaines de l'exploitation minière, de la mise en valeur des ressources pétrolières et du génie civil; la division des ressources hydriques, qui est responsable de la recherche hydrogéologique; et la division des sols, qui effectue des recherches géologiques, géotechniques et pédologiques.*

De l'avis général des industries minières et pétrolières australiennes, la cartographie géologique et le traitement des données géoscientifiques sont les plus importantes fonctions des commissions géologiques et du BMR. Toutefois, en raison d'un manque de ressources, aucun de ces organismes n'offre actuellement un niveau de service satisfaisant, notamment en cartographie. En conséquence, l'ambitieux programme national de cartographie géoscientifique (National Geoscience Mapping Accord) a pris beaucoup de retard. En fait, dans la plupart des commissions géologiques, l'insuffisance des ressources financières et humaines a entraîné un important déclin des activités de cartographie au cours des 15 à 20 dernières années. Si cette tendance ne se renverse pas, il est probable qu'elle aura de profonds effets à long terme sur l'industrie minière (la plus importante du pays), ainsi que sur la gestion de l'environnement et l'aménagement du territoire.

INTRODUCTION

The primary aim of this paper is to give an Australian perspective on the roles and functions of state geoscience agencies, the evolution of their mandates and their jurisdictional responsibilities vis-à-vis the federal agencies, with some comment on how these responsibilities may change in the future.

The development of government geoscience in Australia has been somewhat different from that of most other countries: although separate colonial (later state) geological surveys were established during the mid to late nineteenth century, during the great formative period for geological surveys around the world, a national geoscience agency (the Bureau of Mineral Resources) did not come into being until the mid twentieth century. This is because Australia did not exist as a single nation until 1901, when federation of the continent's six self-governing British colonies took place to form the Commonwealth of Australia. Each of these colonies had established its own geological survey during the second half of the nineteenth century commonly in response to mineral discoveries or the desire for such discoveries. Thus, at the time of federation there was not seen to be any need for a national geological organization. Further, the Australian Constitution, which had been approved by referendum in each colony, delegated only certain powers to the Commonwealth, leaving the rest, including onshore mineral rights, with the states. Accordingly, it followed that geological work should be the prerogative of state governments. This situation remained essentially unchanged until the Commonwealth Bureau of Mineral Resources was set up in 1946. Celebrations for the Bureau's 50th anniversary in 1996 are currently being planned. Reference historical material on the origins and functions of state/territory geological surveys and BMR is contained in papers by Johns, 1976, Crespin, 1965, Denmead,1968, Day, 1990, Playford, 1990 and Cramsie, 1992.

The other federal agency with major responsibilities in geoscience is the Commonwealth Scientific and Industrial Research Organization (CSIRO), which first became involved in minerals research in 1926. Since then geoscience has steadily expanded in several Divisions of CSIRO. The role of these divisions in geoscience however, does not extend to geological mapping and other functions that are normally included in the functions of geological surveys.

ROLE AND JURISDICTION OF GOVERNMENT GEOSCIENCE AGENCIES

State and Northern Territory Geological Surveys

The primary role of the geological surveys is to record and interpret the geology of each state or territory, to provide the results to government, industry and the general public and to advise on relevant environmental, land-use and resource issues. Geoscientific research by the state and territory surveys is primarily field based, concentrating especially on geological mapping, mainly at 1:250,000 and 1:100,000 scales. Detailed research is also conducted in specialist fields such as structural geology, petrology, geochemistry, hydrogeology, basin analysis, environmental geology, metallogeny, geomechanics, geochronology, stratigraphy, paleontology, geophysics and geoscientific computer applications, including database development.

Each of the state/territory geological surveys is part of the respective Department of Mines (or equivalent) and in most cases the director of the survey is responsible to the permanent head of the department.

Several state geological surveys have undergone significant structural changes in recent years, associated with the many official inquiries and reorganizations that have involved government authorities throughout Australia. In some cases traditional geological survey functions, in fields such as hydrogeology, have been transferred to other government bodies or sections of the Department of Mines, thereby weakening the survey concerned. Associated with these changes there have been debilitating staff and funding cuts in several geological surveys. The Geological Survey of Western Australia has been spared most of these problems, primarily because it is situated in the strongest mining state and the survey has received strong political support from industry.

During the past five years funding and staffing for most geological surveys has decreased. Western Australia and the Northern Territory are exceptions with funding increases and Western Australia has also received a modest increase in staffing.

During the same period the budget of the Bureau of Mineral Resources (BMR) received a modest increase to cover costs of services provided by other government departments.

The role of the geological surveys in handling exploration data generated by the mining and petroleum industries has become increasingly important during recent years, especially in Western Australia and Queensland where major expansion has occurred in those industries. The advisory role of the surveys in relation to administration of the Mining and Petroleum Acts and resolution of environmental and land-use issues has also expanded greatly. However, this expansion has not been matched by staff increases, resulting in the reduction of field mapping.

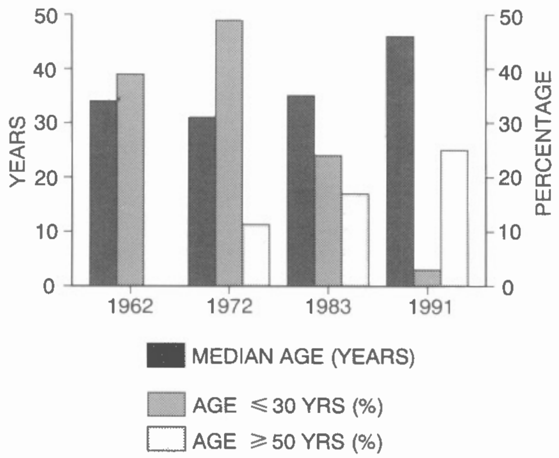
In view of the primary importance of mining in the Australian economy and the fact that geological maps form the fundamental basis for mineral exploration a strong case can be made for staff increases. Mining is now the country's principal industry, yielding the major part of its export income with Western Australia and Queensland as the foremost mining states.

Over the past thirty years large numbers of staff of the Geological Survey of Western Australia resigned during distinct time periods. During the "nickel boom" (1968-71), nearly three-quarters of the staff left and during the years 1979-81 almost sixty percent resigned. These mass resignations resulted from a combination of good prospects for outside employment in the rapidly expanding mining industry and dissatisfaction with various aspects of employment in the Survey.

However, the past 10 years has been a stable period for GSWA in terms of staff retention, despite the recent "gold boom", when the demand for geologists in Australia was at an all-time high. This stability has been very good for the Survey in terms of retention of accumulated expertise, completion of projects and reduction in high costs of recruitment. On the negative side however, staff stability has resulted in a steadily increasing age profile, with decreasing input of new ideas through newly recruited staff. Moreover the many geologists who left the Survey to join industry took with them the special skills gained in regional geology and mapping -- skills that proved especially valuable in company exploration.

Thus, because of the recent low levels of staff turnover, the Survey's staff age profile has increased significantly during the past 10 years (Figure 1) and it seems clear that future staff attrition will be dominated by retirements. Similar age profiles exist in most geological surveys, BMR and many private companies in Australia; it is a symptom of diminished levels of national economic activity.

Figure 1: Age profile, Geological survey of Western Australia.



Commonwealth Bureau of Mineral Resources, Geology and Geophysics

The Commonwealth Bureau of Mineral Resources (BMR) functions as the national geological survey and as advisor to the Commonwealth government, industry and the general public on the geology of the continent and on various environmental, land-use, mineral-resources and related geoscience research of national importance. Much of BMR's geoscientific research is field oriented and mapping is carried out in close co-operation with the geological surveys. BMR is also responsible for geoscientific work in Australia's Antarctic Territory and various island territories. However, unlike most geological surveys, BMR is also responsible for extensive geophysical data acquisition and processing, especially through seismic and airborne-geophysical surveys. In addition, BMR has primary responsibility for earthquake and geomagnetic monitoring and research throughout Australia.

BMR has a greater role than the geological surveys in offshore geoscience because the Commonwealth holds constitutional rights to offshore minerals and petroleum and it can better afford the high costs involved in marine geoscience. However, administration of offshore minerals and petroleum has largely been delegated through legislation to the respective state and territory governments. They have been granted sole rights to petroleum and minerals below the territorial sea (extending to three nautical miles from the coast) and to enclosed waters (bays along the coast and waters between the coast and groups of islands). The Adjacent Area, i.e. waters beyond the three mile limit, is administered by a Joint Authority, consisting of the relevant Commonwealth and state/territory ministers. The state/territory minister has day-to-day administrative responsibility for the Adjacent Area, but the Commonwealth minister has the final say in major decisions. Royalties from production in the Adjacent Area are shared by the Commonwealth and the state/territory concerned.

The role of BMR in geoscientific research changed significantly as a consequence of two government inquiries, in 1978 and 1988. From its inauguration in 1946 until 1978 the primary geoscientific function of BMR, in conjunction with the state geological surveys, had been to map the geology of Australia. By 1978 most of this mapping had been completed to first-edition stage at 1:250,000 scale and the Commonwealth government decided that it was an appropriate time to review the future role of BMR. A report on the matter was prepared for the government by the Australian Science and Technology Council (ASTEC).

The ASTEC report recommended that BMR withdraw from 1:250,000 mapping, passing this role entirely to the geological surveys and that the organization should henceforth concentrate on "strategic mission-oriented research" (Australian Science and Technology Council, 1978). These recommendations were implemented, under the direction of Professor R.W.R. Rutland and during the next ten years BMR withdrew almost entirely from its traditional geological mapping role into other types of research. Most emphasis was placed on petroleum-related research (including a greatly expanded marine component) at the expense of the minerals program.

By 1988 it was clear that the rate of geological mapping in Australia had fallen to unacceptably low levels because of the inability of the state geological surveys to fill the gap created by the withdrawal of BMR from this field. At that time the Commonwealth government instituted a new review of BMR, headed by Mr. A.J. Woods. This was a far-ranging inquiry and in his report Woods (1988) concluded that the geoscientific community had given "a clear message ..... that the emphasis in BMR's work program should be changed. The 'new' emphasis should be on 'state of the art' maps and data sets." In other words, BMR should re-adopt the systematic mapping role that had been relinquished as a result of the 1978 ASTEC report. One of Woods' specific recommendations was that a National Geoscience Mapping Accord be established between BMR and state/territory geological surveys, in order to prepare a new generation of geoscientific maps of the continent.

The Commonwealth government and BMR has since taken action to implement most recommendations of the Woods review and this has resulted in new emphasis being placed on geological mapping and industry-oriented research. Unfortunately, however, this has been accompanied by a decline in BMR's resources including both geoscientist staff and operational funding.

Commonwealth Scientific and Industrial Research Organization (CSIRO)

The other federal agency with major responsibilities in geoscience is the Commonwealth Scientific and Industrial Research Organization (CSIRO). CSIRO's principal geoscientific research is carried out in four Divisions: Division of Exploration Geoscience (73 geoscientists) develops improved geological, geophysical and remote-sensing techniques for mineral and petroleum exploration; Division of Geomechanics (23 geoscientists) undertakes geotechnical studies associated with mining, petroleum development and engineering construction; Division of Water Resources (25 geoscientists) is responsible for hydrogeological research; and Division of Soils (89 geoscientists) undertakes geotechnical and pedological research. The total number of geoscientists in these four divisions (210) is almost the same as in BMR (211). This compares with a total of 315 geoscientists in the combined state/territory geological surveys.

Concern has been expressed from time to time regarding possible duplication of effort between CSIRO and BMR. However, in most areas of geoscientific endeavour it is clear that little or no overlap occurs. For example, the CSIRO Division of Exploration Geoscience does not have a typical "geological survey" role. It is concerned with the development of exploration techniques, a field in which BMR has little involvement. Moreover, research by the CSIRO Divisions is more directly industry driven, in that at least thirty per cent of each Division's working budget must be raised from external sources, mainly from industry. BMR, on the other hand, receives nearly all of its funding from Consolidated Revenue; less than five per cent came from external sources in 1991.

INTERACTION BETWEEN STATE/TERRITORY AND COMMONWEALTH GEOSCIENCE AGENCIES

Close working relationships between the geological surveys and BMR have not always existed. Several states regarded the establishment of BMR as an intrusion into an area of "State Rights" and for many years effectively excluded BMR from operating in all or parts of their territories. Consequently, BMR was not authorized to undertake systematic geological mapping in South Australia and up to the mid 1980's it could not operate in the Precambrian of the Yilgarn and Pilbara Blocks of Western Australia, which remained the exclusive province of the geological survey. It is questionable whether such political restraints, despite their effectiveness, had constitutional backing.

Similar restrictions were placed in some other states. BMR had a completely "freehand" in mapping only in the Northern Territory and Papua New Guinea. When the Northern Territory established its own geological survey and Papua New Guinea became independent, there were concerns in some quarters that BMR could find that it had "nowhere to go".

However, in recent years there has been increasing recognition of the critically important role played by both state and Commonwealth government geoscience in facilitating mineral and petroleum exploration and in advising on geoscientific issues of national importance. There is general agreement that the best interests of the country will be served by close co-operation between the state/Northern Territory geological surveys and BMR through shared responsibility for geoscientific and other research.

The geoscientific activities of CSIRO have generally been warmly welcomed by the state/territory geological surveys; no significant problems of overlapping effort have occurred and there has often been close collaboration in areas of common interest.

THE NATIONAL GEOSCIENCE MAPPING ACCORD

One of the principal recommendations of the Woods (1988) review of BMR was that:

"As a matter of priority, BMR and the state/NT geological surveys, through the Chief Government Geologists' Conference and in consultation with industry and the academic community, develop national geoscience mapping strategy (National Geoscience Mapping Accord) setting out:

- An assessment of current and future national needs;
- priorities;
- goals, objectives and long range plans;
- mechanisms and procedures for monitoring and reviewing the status of maps, map coverage and mapping programs;
- the need for and means of, introducing new technology (ensuring maintenance of standards and compatibility of systems); and
- the resources currently available for this program and those required to achieve desirable levels of activity."

As a result of this recommendation, discussions were held during 1989 between BMR and state/territory geological surveys, the minerals and petroleum industries and academic institutions. Each geological survey produced an outline of a recommended strategy for geological and geophysical mapping programs in its state or territory for the next twenty years. These were collated by BMR to produce a document entitled *A National Strategy For Geoscience Mapping* (Bureau of Mineral Resources, 1990). Part of the proposed strategy was to be included in the National Geoscience Mapping Accord, where mapping proposals regarded as being of national significance for minerals and petroleum development would be the subject of joint projects between BMR and the geological surveys. A total of eighteen areas and projects were identified for scheduled completion by the year 2000 (Figures 2 and 3).

Figure 2: Proposed mapping projects under the National Geoscience Mapping Accord, 1990-98.

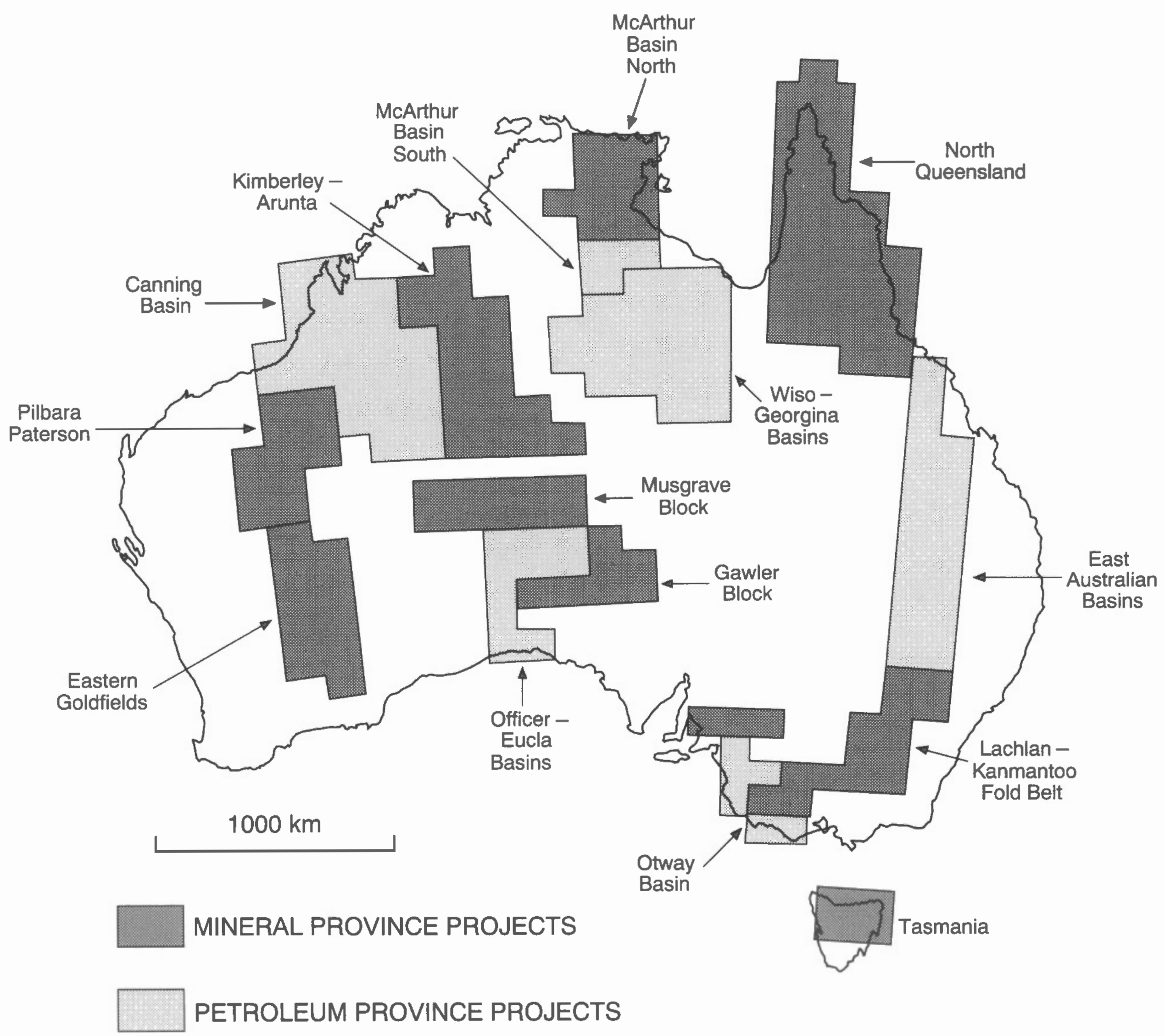
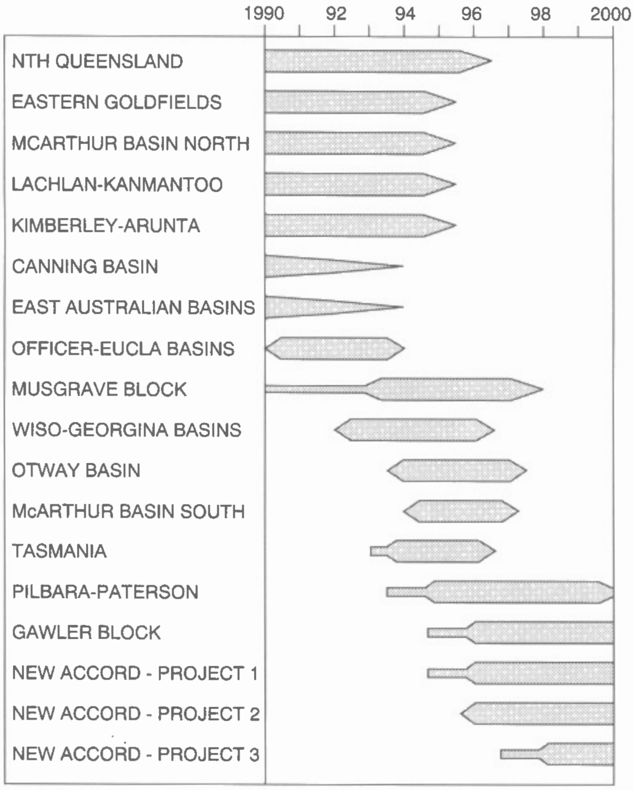


Figure 3: Proposed timetable for completion of National Geoscience Mapping Accord Projects.



The recent report on mining of the Ecologically Sustainable Working Group (1991) drew attention to the importance of the National Geoscience Mapping Accord in providing basic information on the geology of Australia, to assist in developing ecologically sustainable strategies for the mining industry.

When the Accord was first formulated it was intended that it would be the subject of written agreements between the Commonwealth and the various states and the Northern Territory. However, in view of current adverse economic circumstances, the governments concerned have not been prepared to make firm forward commitments to the Accord. Consequently, although the Accord is now being implemented and a number of the proposed projects are well underway, there are no formal agreements in place. Moreover, it was envisaged by Woods that more Commonwealth and state/territory resources would be made available to achieve the desired objectives of the Accord. Again, expectations have not been matched by actions and few additional resources have been made available by the various governments.

Consequently, the laudable objectives of the National Geoscience Strategy and Accord cannot be achieved in the recommended time frame of twenty years, unless a substantial increase in geoscientific resources is made available by both Commonwealth and state/territory governments. Indeed, with present resources it seems unlikely that these objectives can be met in less than forty years.

CONSULTATIVE MECHANISMS

In Australia there is general recognition of the need for research bodies to work together in major research topics, including geoscience. Thus, a number of consultative mechanisms are in place to ensure co-ordination between the work of BMR, CSIRO and the geological surveys and to obtain advice from industry and academia on their respective work programs.

The Australian and New Zealand Minerals and Energy Council (ANZMEC), a council of ministers, has a Chief Government Geologists' Subcommittee, consisting of the Directors of the geological surveys (including the New Zealand Survey) and BMR. The Subcommittee meets at an annual conference to co-ordinate activities and exchange data of mutual interest, such as the development of new technologies. The Director of the Geological Survey of Papua New Guinea is also invited to participate as an observer. The annual conference (two days, plus two or three days on a field excursion) is held on a rotational basis in the respective states, the Northern Territory, Canberra and New Zealand. The 1991 meeting was in Rotorua, the centre of the thermal district of New Zealand and this year's was in Bendigo, Victoria, a historic gold-mining centre.

BMR and CSIRO have had consultative committees in place for many years. BMR Advisory Council includes representatives from the state/territory geological surveys, industry and academia. It meets in Canberra three times a year and its primary purpose is to advise on BMR programs and other activities. Members of the Council are nominated as "godfathers" of particular programs and are expected to monitor the progress and quality of those programs and report on them to the Council.

The Exploration Geoscience Divisional Consultative Committee of CSIRO includes similar representation and objectives and it also has the "godfather" system. It meets once or twice a year, alternating between the Division's two centres: Floreat (a suburb of Perth) and North Ryde (a suburb of Sydney).

In 1986 the Geological Survey of Western Australia (GSWA) was the first to set up a consultative committee and others are expected to follow soon. The GSWA Liaison Committee has representation from the mining and petroleum industries, BMR, CSIRO and university geoscience departments. The committee meets twice a year to discuss and make recommendations on the Survey's rolling five-year program, monitor progress and ensure co-ordination with the work of BMR, CSIRO and academic bodies. Committee members are encouraged to hold discussions with Survey staff members, in order to keep abreast with progress and obtain "grass-roots" views on issues; there are no formal "godfather" appointments. Hydrogeology and Precambrian Subcommittees have been set up to deal with specific aspects of the Survey's program.

Each of these consultative committees serves an important purpose in ensuring that the work of the government geoscience agency concerned is relevant to user requirements and that there is co-ordination between its programs and those of other geoscience agencies and the universities. Many significant changes have been made in the work programs of BMR, CSIRO Exploration Geoscience and GSWA in response to advice received from their consultative committees. There is no doubt that these geoscience agencies have been strengthened within government as a result of their willingness to react positively to user requirements, especially in view of the increasing need for accountability in government.

GEOSCIENCE CONSORTIA

The Commonwealth government has recently provided funds to establish up to 50 Co-operative Research Centres (CRCs) in Australia. Each consists of a consortium of two or more research bodies in academia, government and industry, that are brought together to research a particular theme in science or technology. Funds provided by the government to most centres is between $1.5M and $2.0M per year.

Two CRCs have been approved that focus on exploration geoscience: the Australian Petroleum Co-operative Research Centre and the Co-operative Research Centre for Australian Mining Exploration Technologies. The first, dealing with petroleum exploration and production, is a consortium of the CSIRO Divisions of Exploration Geoscience and Geomechanics, the University of New South Wales and the University of Adelaide. The second, which is to research geophysical methods of detecting ore bodies concealed beneath the regolith, is a consortium of the CSIRO Division of Exploration Geoscience, Macquarie University, Curtin University, World Geoscience Corporation, GSWA and BMR.

Inter-university consortia in geoscience have been established in Victoria and NewSouth Wales and another is expected to be formed in South Australia. In Western Australia it is proposed that a similar concept be extended to include government geoscience bodies as well as universities. The Geoscience Institute of Western Australia (GIWA) is planned to be a consortium of The University of Western Australia, Curtin University, GSWA and the CSIRO Division of Exploration Geoscience. Its purpose will be to raise the profile of the geosciences in Western Australia, to encourage collaborative endeavours between participating institutions and to promote interaction with industry. The Institute will act as a facilitating group to enable the optimum use of staff and facilities in the geosciences in Western Australia.

The Australian Research Council recently commissioned the Australian Geoscience Council to prepare a report entitled *Towards 2005 -- a prospectus for research and research training in the Australian earth sciences* (Australian Geoscience Council, 1992). This report emphasizes the importance of close collaboration between universities and government agencies in the earth sciences. One of its recommendations is that a series of National Geoscience Centres be established, with Commonwealth government funding, to focus on earth science disciplines in which Australian possesses research expertise and on areas of national priority in which it is necessary to enhance geoscientific research and research training. It is envisaged that such Centres will include participation from both universities and government geoscience agencies.

The *Towards 2005* report identified perceived areas of weakness, in terms of expertise or available resources, in research and research training in Australia. Of particular importance to government geoscience is the conclusion that regional geology and geological mapping are weaknesses because of the inadequate resources that are being made available to the geological surveys and BMR. The report recommends "That the Commonwealth and individual state/territory governments substantially increase their level of support for the National Geoscience Mapping Accord, such as will allow the completion of a new generation of earth science maps over the next twenty-year period".

FUTURE RESPONSIBILITIES OF STATE AND COMMONWEALTH GEOSCIENCE AGENCIES

The future division of jurisdictional responsibilities between the state/territory geological surveys on the one hand and the Bureau of Mineral Resources and CSIRO on the other will depend to a large extent on the changing balance of power between the states and the Commonwealth. The trend in recent years has been for Commonwealth powers to increase relative to those of the states.

The changes generally have been accomplished not by referendum nor by the states voluntarily relinquishing their rights, but by the Commonwealth invoking its external-affairs powers under the Constitution. Thus, the Commonwealth has the power to grant or refuse export licences for minerals or petroleum, effectively allowing it to over-ride state authority in relation to mineral production. In this way, the Commonwealth has, for the past nine years, banned further expansion in the number of uranium-mining operations in Australia by refusing to grant additional export licences. As a result, a number of potentially economic uranium deposits cannot be mined, including several in Western Australia.

The High Court of Australia has also ruled that Commonwealth jurisdiction will prevail where any issue impacts on an international convention to which Australia is a signatory. This is expected to be of increasing importance as more global conventions are established relating to conservation and other environmental issues.

If this trend towards increased Commonwealth control continues it is inevitable that Commonwealth geoscience agencies will become more directly involved in issues affecting individual states. However, a growing public view is that there should be a diminution, rather than expansion, in Commonwealth powers. This would be in line with international trends, which show a general movement of power away from central governments towards regional authorities. If this occurs in relation to geoscience in Australia there could be a reversal in the decline that has occurred in many state/territory geological surveys in recent years.

However, I believe that there must be a continuing important role for both Commonwealth and state/territory geoscience agencies in the Australian federation and the current trend towards increasing levels of co-operation between them needs to continue. It is in the long-term interests of the Australian community for these organizations to work closely together in furthering the discovery and development of the country's mineral and petroleum resources.

CONCLUSIONS

In Australia, the general consensus is that geological mapping and geoscience data handling are the most important functions of the state geological surveys and BMR from the point of view of the minerals and petroleum industries and land-use planning. However, none of these agencies are now providing adequate levels of service, especially in mapping, because of the lack of sufficient resources. In most surveys a substantial decline in mapping activity has occurred over the past fifteen to twenty years, associated with falling levels of funding and staffing, and the ambitious National Geoscience Mapping Accord is falling well behind schedule. If this trend is not reversed, it is likely to have long-term adverse effects on the nation's largest industry, mining, and on environmental management and land-use planning.

If mining is to maintain its pre-eminent position in the Australian economy it will be essential to make many new discoveries before existing mines are worked out. Nearly all the discoveries on which existing mines are based were made by following up surface indications of mineralization. Most deposits of this type have probably now been found and the challenge of the future will be to find major "blind" ore bodies -- those with no surface expression. The discovery of such deposits will rely to an increasing degree on the application of sophisticated geoscientific techniques. These include up-to-date geological maps and data sets, produced by combining outcrop observations with various remote-sensing techniques, especially airborne geophysics. The geological surveys and BMR have shared responsibilities for the production of such maps and data sets and it is important for the future development and prosperity of the Australian earth-resource industries that they work closely together and be provided with adequate resources to meet these responsibilities.

The Role of Canada's Provincial/Territorial Geological Surveys Circa 2000

W.D. McRitchie[1]

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Abstract

The Provincial and Territorial Geological Survey organizations are described in the context of their past and current roles of assisting and fostering exploration of Canada's mineral endowment. The various components and structures of the Surveys are compared, as are their relationships to other federal and provincial government organizations, universities, and the mineral industry. Numerous different approaches have been used in the past to optimize the limited financial and human resources available to the Surveys. Even greater ingenuity will be required in the future as the Surveys' roles expand to encompass a growing demand for information to resolve land-use issues, native land claims, and environmental concerns, at the same time as communicating more effectively with mineral explorationists, and assisting the increasingly complex and costly search for deeply buried ore deposits.

Résumé

La communication décrit les commissions géologiques des provinces et territoires dans le contexte de ce qu'elles ont fait et de ce qu'elles font pour aider et stimuler l'exploration des richesses minérales du Canada. Elle compare les divers éléments et les diverses structures des commissions géologiques, ainsi que leurs rapports avec d'autres organisations fédérales et provinciales, avec les universités et avec l'industrie minérale. Les commissions géologiques ont utilisé diverses formules par le passé pour tirer le maximum des faibles ressources financières et humaines dont elles disposent. Il leur faudra faire preuve d'encore plus d'ingéniosité dans les années à venir, parce que leur rôle est appelé à s'élargir: elles devront répondre à des demandes croissantes d'information pour résoudre les questions d'occupation des sols, des revendications territoriales des autochtones et d'environnement, tout en communiquant plus efficacement avec les intervenants de l'industrie minérale et en facilitant la recherche des gîtes minéraux profondément enfouis, qui devient de plus en plus complexe et de plus en plus coûteuse.

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INTRODUCTION - OPERATIONAL ENVIRONMENT

Over the last ten-twelve years, a host of international forces have led to increasingly competitive trade relationships, and diversified economies with a trend towards rapidly expanding information-based technologies, and increased growth in the service sector. These structural changes have been paralleled by a growing sense of social and fiscal concern that has triggered serious commitments by governments at all levels to avoid passing on fiscal and environmental deficits to future generations (the latter manifested as the Sustainable Development Mission). In Canada, the federal government is giving serious consideration to transferring certain responsibilities (and consequently, fiscal obligations), to the provinces. Other reductions in federal services (e.g. scientific research and development) have also increased pressure on the provincial governments to assume some of these responsibilities.

For the provincial and territorial geological survey organizations in Canada (already fettered with extreme budget constraints and limited human resources), the prospect of having to assume more of the functions previously delivered by the federal government will constitute an interesting challenge. If they materialize, these additional responsibilities would compound current difficulties of responding to demands for increased levels of geological mapping and support from the sorely stressed exploration sector, as well as an expanded and growing involvement with a wide variety of environmental and land-use issues. Nevertheless the prospect of developing greater, long term, autonomy in the regions (for delivering geological programming), has always been a factor in provincial debates, and deliberations. Accordingly, the current trends can be looked at as providing, perhaps, an opportunity as well as a challenge.

Since the responsibilty for managing their natural resources is vested in Canada's provincial governments, the provincial geological surveys in many respects have the same level of responsibility, and accountability, to their mineral and energy industry clients as do federal surveys in the USA and other countries. Consequently, faced with the current recessionary economy, and increasing competition for mineral investments from third world countries, it is inevitable that, at least in the short term, the main thrust of the provinces'/territories' geological work will continue to be the definition of their respective mineral endowments, and the promotion and fostering of new mineral developments within their respective domains. Close collaboration and cooperation with the Geological Survey of Canada will be essential if these efforts are to make the most of the sparse resources available to do the job.

If at the same time, the federal and provincial administrations are commited to pursuing responsible and effective land-use management policies and environmental practices, then the provincial survey organizations must lobby for additional/reprofiled resources to ensure they too can play an active role in all such new developments, both as an advocate for the mineral sector, and as an impartial expert on the most fundamental of earth sciences, geology.

PROVINCIAL GEOLOGICAL SURVEY ORGANIZATIONS-COMPONENTS/STRUCTURES

Since their inception, the provincial surveys have maintained close working relationships with the private sector, and have focused their efforts almost entirely on supporting mineral exploration and development by providing detailed geological maps and reports of prospective areas, systematically documenting mineral deposits, and giving advice to prospectors on where, and how best, to look for various types of mineralization, or mineral commodities. The emphasis given to the various categories of programming varied across the country.

Most provinces embarked on one mile to the inch geological mapping following World War II, then expanded this approach to encompass systematic 1:50,000 scale regional mapping programs during the early nineteen seventies. First-pass coverage of important mineral belts was, with the exception of B.C., completed in most regions by the end of that decade. It was not until 1986 that systematic geological mapping at a scale of 1:50,000 was initiated by the British Columbia survey.

Throughout this period the Geological Survey of Canada gave regional dimension to the provincial vignettes by undertaking systematic 1:250,000 geological mapping programs, supplemented by more detailed coverage in selected areas.

Although all provinces maintain Geological Survey organizations, these vary considerably in size and range of activity (Table 1). The scope and scale of each survey's operations is determined both by the population/tax base that the government can draw upon, as well as the peculiarities of the terrain and resource potential encompassed by their provincial boundaries. Some Geological Surveys possess large hardrock contingents, and the work carried out is biased towards belts or terrains with higher mineral potential. Others show a bias toward Phanerozoic subsurface investigations; some maintain a balance of the two, and yet others are large enough to also include major components of geochemical and geophysical specialisation.

Table 1: Provincial Geoscience Expenditures, 1990-1991

Province/ Territory	Surv Expend $ x 10^6	% of Total	Area of Prov/Terr km^2 x 10^3	Survey $/$km^2$	Population (1986) x 10^3	Survey $ Capita
Newfoundland	4.8	6.4	405	11.8	568	8.5
Nova Scotia	3.8	5.1	55	69.1	873	4.4
Prince Edward Island	-	-	6	-	127	-
New Brunswick	2.3	3.0	73	31.5	709	3.2
Quebec	17.3	23.0	1 541	11.2	6 532	2.6
Ontario	19.9	26.5	1 069	18.6	9 102	2.2
Manitoba	3.6	4.7	650	5.5	1 063	3.4
Saskatchewan	4.4	5.9	652	6.7	1 010	4.3
Alberta*	8.6	11.4	661	13.0	2 366	3.6
British Columbia	7.8	10.4	948	8.2	2 883	2.7
Yukon	1.4	1.9	483	2.9	24	58.3
Northwest Territories	1.3	1.7	3 380	.4	52	25.0
Totals	75.2	100.0	9 923	-	25 309	-

*Includes other provincial agencies

Typically petroleum and water resources are excluded from the sphere of concerns addressed by the provincial geological surveys (Table 2), and are affiliated instead with the departments responsible for monitoring and regulating the energy and petroleum sectors. The principal exceptions are Saskatchewan where a major Petroleum and Natural Gas Branch functions within the Minerals Division, and Alberta, where the Alberta Geological Survey is part of a Crown provincial research organization (Alberta Research Council), and has historically been dominantly focused on oil sands, heavy oil and coal programs. Commencing in 1990, the Alberta Geological Survey is co-managed by ARC and the Alberta Department of Energy. Some provinces maintain separate Water Resources Branches within the Departments of Environment or Natural Resources.

Suitable linkages are maintained between departments, either on a one-on-one basis between professionals, or through standing- or task-oriented technical advisory committees.

Most provincial surveys include surficial geology sections, and in some regions these also contain units targeted at aggregate resources. In Alberta and Saskatchewan the surficial geology program is mounted through the Research Councils. Across Canada, a major component of the Quaternary geologists' efforts is currently being devoted to basal till studies and boulder tracing in support of private sector base and precious metal exploration programs.

Although most provincial/territorial surveys in Canada are experiencing an increased involvement in land-use issues, the British Columbia survey anticipated this demand ahead of its counterparts and had designated these responsilities to a specific Land-use Unit. However in a recent reorganization, responsibilty for land-use issues was subsequently transferred to a separate branch responsible for Mineral Policy.

Industrial Mineral Units throughout Canada, though generally quite small, are actively engaged in assessing

Table 2: Operational capabilities of the provincial geological surveys (in addition to mapping and min. dep. documentation)

Province	Wtr Res Hydgy.	Land Use	Surf.	Coal	Petro & Nat. Gas	Enviro.	Drill Op.	Ind. Minerals
BC	OD	R	I (as)	I	R	N	I	I
AB	I/R/OD	R/OD	R	I	I	I/R	N	I
SK	OD	OD	OD	OD	I	OD	I	OD
MN	OD	R	I/s R/a	-	R	OD	I	I
ON	OD	R	I/S I/a	N	R	R	I	I
PQ	OD	R	I	R	R	R	I	I
NB	OD	R	I	R	R	N	I	R
NS	OD	R	I/s	R	R	N	I	R
NF	OD	N	I	R	R	N	I	I
PEI	OD	?	I	N	R	R	N	I
Y	OD	N	I/OD	OD	OD	I/R	N	I

Abbreviations: a–aggregate, S–support, OD–other department, I–in Branch, R–affiliated Branch, N–none, s–surficial unit.

Table 3: Minerals-oriented resources by province (# agencies)

Resource	BC	Alta.	Sask.	Man.	Ont.	Que.	N.B	Lab. Nwfld	N.S
Provincial Surveys	1	1	1	1	1	1	1	1	1
Federal Surveys	2	1	-	-	1	1	-	-	1
Research Institutes	1	1	1	-	ROM+1	2+Meri	1	-	1
Universities (giving Geology graduate courses)	3	3	2	1	14	7	2	1	4

ROM: Royal Ontario Museum
Meri: Mineral Exploration Research Institute

and promoting the diverse potential in each of the provinces. Not all provinces contain coal resources, but those that do have a coal geology program.

Analytical, Cartographic, and Lapidary Units are important support components to any modern professional survey, and few if any of the provincial surveys are totally dependant on external suppliers for these services.

Mineral Exploration Liaison committees are maintained by all provinces with representation from various industry groups, and the Geological Survey of Canada (Quebec and Alberta maintain permanent advisory committees).

Accountability is maintained through regional meetings, workshops, and annual Open Houses, at which time all of the current years work is displayed, and reviewed in general and/or theme/topic specific talks.

Linkages and cooperative research with university groups are well established. In most provinces the present level of this activity is significantly, although not exclusively, developed and dependant on Mineral Development Agreement (MDA) funding.

Several provinces support research councils or institutes (Table 3), whose activities augment those of the geological surveys. Many provinces maintain Regional or Resident Geologist offices which may be an integral component of the survey itself (BC, Sask., Man., Que., NB., and NS.), or part of a separate regional organization.

COMPARISONS BETWEEN PROVINCIAL GEOLOGICAL SURVEYS

Comparisons between geological surveys tend to look simply at the staffing levels and budgets that each agency has to work with, compare these with the total value of mineral production in the region, and on a percentage basis conclude that the agency is either well served by its administration or under-funded, compared to other provinces.

A typical table of statistics (Table 1), taken from the most recent Provincial Geologists Journal, is included as an example. Additional statistics compare the respective ages of the provincial and territorial surveys and their growing responsibilities and capabilities over the years.

Obviously the size of the organization and its resources are significant in determining the workload and range of capabilities that it might have. However numerous other factors have to be taken into consideration when making a comparison of this nature.

Constraints imposed by harsh climate, lack of infrastructure and difficult terrain can dramatically increase the amount of time required to document an area. Geological complexity also places limitations on the interpretation (in isolation), of statistics that compare person years and expenditures to unit area. Large tracts of the country are blanketed by surficial deposits that preclude bedrock studies, and the time taken to map a complex greenstone belt will vastly exceed that required for a homogeneous granitic batholith, or undeformed, flatlying Paleozoic dolomites.

Comparison of current statistics may also ignore the maturity and quality of the geoscience database (Table 4). Furthermore, in some provinces, other agencies may be undertaking similar work, even though the mandates are not identical. In this respect, it is important to note that the unique geology and mineral potential of British Columbia is engaging the attention of a wide range of geoscientists working for the federal geological survey in Vancouver, Sidney, Calgary and Ottawa, as well as researchers from the Universities of BC, Simon Fraser, Victoria and the Royal Roads Military College, and several universities in the USA.

The maturity of the British Columbia geological survey, founded as the B.C. Bureau of Mines, in 1895, compares favourably with that of the Ontario survey (1891). They are about 30 years younger than the surveys in Atlantic Canada, and 30 years older than the other surveys in Western Canada.

The Territorial agencies are truly in their infancy, having just begun over the last five years, to participate in and co-manage geoscience programs under cooperative federal-territorial economic development agreements. These programs have allowed territorial geoscience agencies to develop expertise and experience designing, budgetting, managing and administering programs in conjunction with the federal agency (DIAND) that had in the past, the responsibility for managing and administering mineral resources in the territories. In this context we can say that this transition of responsibilities provides an ideal example of the "Evolution of Geological Surveys Over Time (and Space)".

Table 4: Provincial/Territorial Geological Surveys - record of progress

Province	Date of Founding	First Systematic Mapping	Main Regional Thrusts	First "Total" Coverage
Newfoundland	1864	1930	1974	1972
Nova Scotia	1865	1950s	1970s	late 60s
New Brunswick	1846	1933	1952/70	1979
Ontario	1891	1905	1962/63	1972
Quebec	1891	1939	1960	1963
Manitoba	1930	1946	1970	1979
Saskatchewan	1931	1947	1970s	1973
Alberta	1921	1921	1921	1926
British Columbia	1895	1986	1986	-
Prince Edward Island	(presently unavailable)	-	-	1985
Territories				
Yukon	1969	1900*	1960s	1974
NWT	1969	1972	-	-

*Klondike

And now the future, as far as we can project from current trends.

CURRENT STATUS AND ISSUES FACING THE PROVINCIAL GEOLOGICAL SURVEYS, 1990-2000

The decade of the 90's will present an impressive array of new challenges to the provincial geological survey organizations. These will include a rapidly expanding mandate to address environmental, geological hazard and land-use concerns, an elevated level of cooperative interagency program delivery, the need to upgrade archival databases for compatibility with electronic processing techniques, more rapid turn-around for map and report production, and more effective and widespread representation on intergovernmental and interagency industrial development committees. All of this will have to be accomplished at the same time as maintaining the traditional inventory (mapping), service and research functions, and in the face of fiscal restraint. Additionally it is widely recognized that major efforts must be made by the surveys to communicate more effectively with industrial clientele, with the public, and with decision makers both in government and the private sector, so that the significance and future application of their work (and that of the mineral sector), can be appreciated in the context of solving the problems confronting our society.

Fortunately the provincial surveys (through various provincial, interprovincial, federal/provincial and interagency committees), are aware of these demands, and have already made adjustments to take on some of these new responsibilities. The recent (1984-89) Mineral Development Agreements (MDA's) played a key role in focusing outputs generated by the surveys, and in providing hands-on experience with parallel federal/provincial program delivery, as well as joint management structures. With appropriate and continued support the provincial surveys and their federal counterparts will be able to extend and consolidate the framework for effective, cooperative (federal/provincial/industry/university) program planning and delivery which has been established over the last 5-10 years.

From a human resource perspective there is a very real concern regarding the surveys' ability to phase in the next generation of professional staff. Demographic studies have recently highlighted the fact that a major proportion of professional geologists working in government are at a relatively advanced age: 30% may retire by the turn of the century. Another 50% are in the age range 35-49, so there is every possibility that they will soon either be in management positions or unlikely to undertake lengthy field seasons. Ultimately this could lead to cutbacks in the level of new data acquisition, unless concerted efforts are made to instill new blood into the organizations as soon as possible. Here too, difficulties are likely to be encountered if current trends in university enrollment in earth science undergraduate and graduate studies continue to show the alarming decline apparent since 1984.

On the positive side, the relative stability of the provincial surveys over the last 10-15 years, and depth of experience of their geologists reflects an unique pool of knowledge and insight into each region's geological attributes. The 1990's will therefore also present an opportunity for provincial survey managers to capture these perspectives by mounting appropriate synoptic and compilation initiatives. Some, such as the Geology of Ontario, have already been accomplished.

Next we will look at the future of the surveys from an operational perspective.

GEOLOGICAL MAPPING AND MINERAL DEPOSIT DOCUMENTATION

Recent reviews of Canada's base metal reserves indicate a progressive decline in zinc (27% since 1975), and copper (18%). Although ore reserves are a function of metal prices, this dramatic fall-off in base metal reserves is one of the most critical problems facing Canada, and for this situation to be rectified a major new exploration thrust must be initiated by industry. For the federal and provincial surveys this has been translated into programming that (with renewal of the MDA's), would see significant increases made in the rate at which new geological maps are produced for the more prospective areas. In Manitoba new multidisciplinary GSC investigations (EXTECH), primarily using federal A-Base funding, and with help from the provincial survey, are being focused into mining camps to define the controls localising mineralization. These studies will also entail an evaluation and enhancement of geophysical techniques that would sharpen the focus of exploration for more deeply buried ore bodies.

Systematic documentation of mineral occurrences is expected to continue throughout the next ten year period, together with mine-specific studies and metallogenic modelling. Some provinces are giving, and will continue to give, increased emphasis to industrial mineral investigations opening up further alternatives for diversifying the mineral base.

MINERAL DEVELOPMENT AGREEMENTS (MDA'S)

In general, cooperative working relationships between the provinces and the federal government have been in place with only minor breaks since the early seventies. The funding formulae and balance of program delivery have varied over the years. The MDA's have, in general, proven to be an effective mechanism for supporting regional economic development, and substantial advantages have accrued through their implementation, especially in the "have-not" provinces. The most recently completed round of agreements (1984-1990), involved many cases of parallel program delivery with agencies in Energy Mines and Resources Canada. The provinces benefited not only from the influx of federal programming, but also from the infusion of discrete yet complementary federal expertise, and technological contributions. Joint workplans were developed annually with cooperation from industry through advisory and liaison committees. The programming was monitored by federal/provincial management committees with emphasis given to high visibility, and rapid dissemination of outputs. MDA's in several provinces also included initiatives addressing both the development and exploration sectors of the mineral industry.

However, MDA programs only represented between 20-50% add-ons to base programs. It is clear that effective joint-management mechanisms for the other 80-50% of activities must be put into place, to ensure that federal contributions meet the regional needs and objectives.

The private sector appeared well pleased with the approach developed by both levels of government, and lobbied vigorously for renewal of the MDA's into a second five-year term (i.e. 1991-1996). At the time of writing new Agreements for the Maritime provinces are in place, as are those for the Yukon, NWT, Ontario, Saskatchewan, Manitoba, and Alberta.

If the provincial surveys are to be successful in attempting some of the initiatives expected of them over the next ten year period, renewal of the MDA's will be essential in the short term. However, there is a growing awareness that the provincial surveys have become unduly dependant on the continuity of federal supplements, and to redress this situation several provinces have argued for increases to their A-base budget levels to permit continuity of baseline programming independant of federal/provincial agreements.

NATMAP

A concern that the rate of geological mapping in Canada was inadequate to meet contemporary and future needs, prompted the Geological Survey of Canada to come forward with the concept of a National Geological Mapping Program (NATMAP). All provinces have been invited to take part in honing the concept, and joining in the process of mounting a coordinated approach to enhancing and modernizing the documentation of Canada's geological endowment. At the time of writing two NATMAP projects are underway (Shield Margin-Manitoba/Saskatchewan; Great Slave Province-NWT), a third (Southern Prairies) is in an advanced stage of development, and several others are on the drawing board with schedules that could see implementation in fiscal 1992/1993.

The provincial surveys are also participating in aspects of the LITHOPROBE and CONTINENTAL DRILLING initiatives. These too will make demands upon the time and efforts available to address other new issues.

ENVIRONMENTAL MONITORING, LAND-USE ISSUES AND GEOLOGICAL HAZARDS

Many environmental issues contain an important geoscience component. Although self-evident to most geologists, this fact is obscured to some extent because provincial geological survey organizations have not traditionally been called upon to provide input to such matters (the environment has not always had the pre-eminent role that it does today in government strategies). Consequently the track record of using geological expertise to successfully resolve environmental dilemmas is not extensive in Canada. Furthermore there is a tendency, in some special-interest groups, to regard anything, and anyone related to geological surveys as having a somewhat pro-industry, developmental bias.

Active conservation programs are in effect in several provinces including those identifying geological sites with an unique natural or scientific value (e.g. Areas of Natural and Scientific Interest - ANSI in Ontario). Some provinces lacking such a program are giving thought to developing equivalent practises, with attendant demands on time required to draft the appropriate legislation.

In other provinces strident efforts by environmental groups and naturalists have seriously encroached upon the amount of territory available to developers, prompting governments to initiate a "No alienation without evaluation" policy. This ultimately results in the provincial geological surveys having to undertake a preliminary assessment of the mineral resource potential in all areas slated for conservation. Both the federal government and the province of British Columbia have established formalized processes for this type of evaluation, with funding contributions coming from all agencies having a vested interest (i.e. Parks, Indian Affairs, and Mineral Resources).

Virtually all provinces have experienced the same outburst in demand for geological information, and boardroom participation, as a counterpoint to the upsurge in environmental lobbies, Endangered Spaces campaigns, expansion of Provincial Parks, and alternative land-use proposals threatening sterilization of mineral resources. Geological personnel more familiar with the field environment, have had to learn new debating and negotiating skills in order on the one hand, to provide informed, objective geoscience-related information to government and the public sector, and on the other hand to represent the mineral development perspective effectively. There is also a growing awareness of the need to have equivalent-rank representation in the boardroom, as well as the need to maintain a "hot-line" between personnel handling the conflicts and decision makers at Head Office. The increased workloads are compounded in several provinces by Native Land Claims, which also require advice from the provincial/territorial surveys as custodians of the minerals data-bases. To meet this growth in demand, some provincial surveys have established Land-use units, and others are giving consideration to doing so.

Certain parts of Canada (particularly British Columbia), are prone to natural hazards such as earthquakes, landslides, avalanches, rockfalls, volcanism, and tsunamis as well as floods and shoreline erosion. In these regions discussions are well advanced, and could result in significant provincial programming to classify the respective geological hazards in a manner that would prompt and guide future municipal and housing developments.

ELECTRONIC DATA PROCESSING

All provincial surveys are in the throes of applying and evaluating computer hardware and software packages that might enhance their ability to collect, store, process and analyse the huge volumes of data that have been accumulated and archived over the last century. Most agencies have been deeply involved since the early 1970's, some have spent large amounts of time and money evaluating various systems. Others with less resources have waited on the sidelines, monitoring each new claim of progress, and occasionally stepping in to acquire or maintain a hands-on involvement.

The state of the art in electronic data processing across Canada is highly variable. However a growing number of efficient and inexpensive database management systems are now emerging, and most provincial surveys have computerized mineral deposit datafiles, and use word processing and desktop publishing (DTP) systems for developing their reports. Saskatchewan, in 1988, was the first agency to produce its annual report of field activities using DTP. Ontario has since established an electronic fast turn-around printing system ("Fast-track") that permits release of reports and colour maps within 6 months of manuscript completion. Adoption of this approach by all provinces would remove one of industry's principal longstanding complaints concerning delays in survey publication releases.

All provinces are also heavily involved in evaluating sundry Geographical Information Systems (GIS), either independently, in cooperation with the GSC, or as part of a wider provincial GIS appraisal. Although several systems are in use, no province can claim to have a fully operational GIS, but rapid advances can be anticipated in the immediate future. Several, if not all of the longer range plans for programming during the 1990's contain budgets with significant components dedicated to electronic data management, application, and information transfer.

COMMUNICATION

"Geology and geologists have become more specialized, their language more complex and obscure to the general public, their erudition more focused toward their scientific colleagues than on outsiders, and perhaps even their attitudes less focused on general societal concerns than on their own narrow self interests. This situation has led to a deplorable lack of transfer of information from the geologic community to the political decision makers......

....geological scientists who talk only to other geological scientists have little impact on the society. It is only when such information is translated and transmitted to decision makers that the science of geology serves the needs of society. Whether or not we wish to admit it, that translation is the responsibility of geologists; the public and private decision makers are not equipped to do it ." (Simon 1982).

Although a decade has passed since the above concerns were voiced, it is widely acknowledged that major efforts are still required in communicating to the public, and to decision makers in government, the importance of geological survey work to the wealth-generating and quality-of-life aspects of our society. Marked advances were made by some provinces through promotional and educational programs during the recent MDA's (in cooperation with the GSC). But obviously this problem must be addressed by a much longer term campaign. Similar government programs, in the future, will deserve substantial and continued support.

The need to enhance the mining sector's image is being addressed independently by the mineral industry through its own public relations initiatives, and an overhaul of its mining practises, as well as within the surveys' workplans scheduled for future MDA's. Communications will continue to play an important role in getting the message out to the public. But this responsibility must also be addressed in communications to those decision makers who hold the purse strings, in order that the provincial *Surveys* can compete successfully with other departments for limited financial resources.

In this respect, provincial survey managers should give greater ear and attention to the needs of program evaluators, and make a point of recording the statistical records of performance that will be used in defense of future budget requests. Budget proposals previously couched in scientific jargon are increasingly being replaced by strategic, business and action plans that clearly define the objectives of the organization, together with milestones and deliverables.

CONCLUDING STATEMENT

In conclusion, it can be said that Canada's provincial and territorial survey organizations have played an unique role in facilitating, coordinating, and cultivating an enhanced awareness of the proven and potential value of each region's mineral and energy endowment. In the past this has been heavily weighted toward assisting industry in the search for prospective ground.

The next decade will be one in which we as survey managers, will be called upon to communicate with much greater clarity and forcefulness the very real contribution that geological survey work can make to each societies' economic and social wellbeing.

We have chosen to focus our lives in developing an understanding of how this planet works, how it has evolved, and how we can benefit from its riches. In the years ahead we, as survey managers, must demonstrate how these skills and insights are indispensible to executive managers and politicians responsible for devising and implementing strategies for sustainable development, and responsible land-use management.

The technical capability and geological insight of the organizations and individual geologists comprising Canada's provincial geological surveys has continued to grow throughout the 20th century, and is now poised to make substantive contributions to Canada's future growth, and quality of life.

Every effort must therefore be made to see that this potential is protected through the current economic malaise, and is given a firm basis on which to express itself in the 21st century, in the field, on the screen, through computer-generated hardcopy, and in symposia such as this.

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State Geological Surveys of the United States of America: History and Role in State Government

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Abstract

Early in the 19th Century, as the fledgling United States of America expanded its borders, its growing appetite for raw materials was accompanied by an increasing awareness that geological conditions and mineral resources would play a major role in the development of our lands and provide the feed stock for our industries. State geological surveys were created by state legislatures to evaluate their respective states' resources and to report the results to the public. The first state survey was established in 1823 in North Carolina. Most of the early surveys were given finite time limits to complete their work, after which they were to be abolished; thus, many early surveys had short lives. None that were established before the New York State Geological and Natural History Survey in 1836 have continued without interruption. By 1869, nevertheless, some 30 state geological surveys were operating.

The scope and function of research in these early surveys were shaped by some of the great early pioneers in geological sciences, such as David Dale Owen, first State Geologist of Indiana and second State Geologist of Kentucky; William W. Mather, Regional State Geologist in New York, first State Geologist of Kentucky, and first "Principal" Geologist of Ohio; Charles H. Hitchcoch, second State Geologist of Maine; Edward Hitchcoc̆h, first Director of Surveying in Massachusetts; Henry D. Rogers, first State Geologist of New Jersey and first State Geologist of Pennsylvania; James Hall first Director in New York and first State Geologist in Iowa; and many other distinguished geologist administrators.

Today many of those surveys have celebrated their sesquicentennial anniversary. Although diverse in size, name, and scope, the 50 functioning state geological surveys, whether staffed by a lone State Geologist or a large group of scientists, share the basic responsibility to delineate the geologic resources and assess geologic conditions as they affect the economic and environmental well being of their respective states. The responsibilities of the various state geological surveys differ according to the legislation and traditions under which they evolved, but almost all serve as a basic information source for their state government's executive, legislative, and judicial branches. Some have regulatory responsibilities for water, oil and gas, land reclamation, and other mineral extraction and land-use activity; others are non-regulatory. Many work in cooperation with the U.S. Geological Survey to address issues that are common to both the State's and the Nation's interests, especially in geologic studies, water resource evaluation, and topographic and other types of map production.

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Résumé

Aux débuts du siècle dernier, alors qu'elle repoussait ses frontières, la nouvelle nation des États-Unis avait un besoin croissant de matières brutes et prenait de plus en plus conscience de l'important rôle que sa géologie et ses ressources minérales joueraient dans la mise en valeur de son territoire et dans l'expansion de ses industries. Les divers États ont créé des commissions géologiques et les ont chargées d'évaluer les ressources de leur territoire et d'en faire rapport au public. La première commission géologique d'État a été créée en Caroline du Nord, en 1823. La plupart des premières commissions géologiques devaient terminer leurs travaux dans des délais précisés, après quoi elles devaient être dissoutes. C'est ainsi qu'un grand nombre d'entre elles ont eu une brève existence. Aucune des commissions créées avant la Commission de géologie et d'histoire naturelle de l'État de New York, fondée en 1836, n'a continué d'exister sans interruption. Néanmoins, on comptait en 1869 une trentaine de commissions géologiques d'État.

La portée et la fonction des recherches effectuées par ces premières commissions géologiques ont été modelées par certains des pionniers des sciences géologiques comme David Dale Owen, premier géologue d'État de l'Indiana et deuxième géologue d'État du Kentucky; William W. Mather, géologue d'État régional de New York, premier géologue d'État du Kentucky et premier géologue principal de l'Ohio; Charles H. Hitchcoch, deuxième géologue d'État du Maine; Edward Hitchcoch, premier directeur des levés géologiques au Massachusetts; Henry D. Rogers, premier géologue d'État de New Jersey et premier géologue d'État de Pennsylvanie; James Hall, premier directeur à New York et premier géologue d'État de l'Iowa; et de très nombreux autres administrateurs géologues distingués.

Aujourd'hui, un grand nombre de ces commissions ont célébré leur 150^{e} anniversaire. Bien que leur envergure, leur nom et leur champ d'action puissent varier, les 50 commissions géologiques d'État, qu'elles comprennent un simple géologue d'État ou un grand nombre de scientifiques, ont la même responsabilité fondamentale : recenser les ressources géologiques et évaluer les conditions géologiques qui influent sur le bien-être économique et écologique de chaque État. Les responsabilités des diverses commissions varient selon la législation et les traditions qui ont dicté leur évolution, mais presque toutes servent de source d'information aux pouvoirs exécutif et législatif et à la magistrature de l'État. Certaines sont chargées de réglementer l'eau, le pétrole et le gaz, la remise en valeur des terres et d'autres activités d'exploitation minérale et d'occupation des sols. D'autres n'ont aucun rôle de réglementation. Un grand nombre d'entre elles collaborent avec la Commission géologique des États-Unis à l'étude de questions qui intéressent à la fois l'État et la nation, notamment des études géologiques, l'évaluation des ressources hydriques et la production de cartes topographiques et autres.

The Association of American State Geologists is pleased and proud to have been invited to speak on behalf of the 50 state geological surveys in the United States of America at this most significant International Conference of Geological Surveys. Because the state surveys were the earliest organized governmental geological agencies in the United States and preceded the founding of the U.S. Geological Survey by more than 50 years, it is appropriate that their record be placed before you.

The state geological surveys have a record of monumental accomplishments, both scientific and applied. It is a record of geologists of great distinction and of their travails in areas of budgets, politics, and policies. A detailed account of each of the state geological surveys can be found in our recently published book which the association put out a couple of years ago, *The State Geological Surveys -- A History*, compiled and edited by Arthur Socolow (1988)

The first state geological survey, in North Carolina, was founded in 1823. By 1879, when the U.S. Geological Survey was founded, 36 state geological surveys were already in existence. During the mid-1800's, several state surveys had sporadic and limited lives. The prevailing belief was that a survey could, within a designated few years, complete the mapping of the geology and mineral resources of the given state and then cease to exist. State officials did not realize, however, that geologists never complete projects - they simply invite the need for new and additional projects. Thus, several state surveys have gaps in their historical record that lasted until the respective state governments could be persuaded of the merits of continued mapping and research.

I must point out that whenever we speak of the 50 state geological surveys, we are referring to 50 discrete agencies with diverse names, size, and functions. Yet all have the common responsibility to delineate the geologic framework and mineral resources of their respective states as they relate to the environment and economy.

Permit me to elaborate on the matter of diversity. The names of the surveys include such variations as the New York State Geological Survey, California Division of Mines and Geology, Pennsylvania Topographic and Geologic Survey, West Virginia Geological and Economic Survey, State Geologic and Natural History Survey of Connecticut, and Hawaii Division of Water and Land Development. The titular head of each of these state surveys is designated as the State Geologist. About half of the state surveys are based in their state capitol city, and half are at their state university.

The state surveys range in size from a staff of 146 in Illinois to 1 in Massachusetts and Rhode Island. The total staff of the 50 state geological surveys currently numbers 2,162 full-time employees, with an average of 42 per state. The staff sizes have no direct relation to state population, area, nor value of mineral production; they relate to the staff's ability to promote within their parent agencies and the state budgetary process, the role and purpose of geologic research and services within the state.

In the most recent year the operating budgets of the 50 state surveys amounted to a total of $129 million, of which $15 million was contributed by federal agencies. Individual budgets range from $13 million per year (Texas and California) to about $50,000 in Rhode Island. In the current and coming fiscal years, austerity pressures are creating budget and staff reductions that are severely challenging the surveys' leadership to avoid suffering more than their fair share of the cuts. Important as we geologists know geology to be, competition with hundreds of busloads of demonstrators who oppose cuts in social service programs is difficult.

I will now focus on the functions and history of the state geological surveys. As the diversity of the titles of the organizations suggests, the 50 state surveys have a variety of responsibilities in addition to their basic charge to carry out the dual functions of geological research and public service. Among the states, differences in geologic features and resources have resulted in a vast diversity of projects. Let me emphasize that state surveys have not only provided routine advisory responses to state needs, but they have also brought forth a multitude of major scientific advances and breakthroughs in geologic principles and knowledge. I might note that as of today, some 11 state geological surveys also have been assigned regulatory duties in the areas of water, coal, oil, and gas. Having served as director of the Pennsylvania Survey during a four-year period when we were assigned the responsibility of oil and gas regulation, let me urge that if any of you have the option to refuse regulatory responsibilities, do so. It is a no-win situation.

Historically, the state surveys came into being in the early 1800's to delineate the mineral resources of the states and to define the geologic conditions that affect development. As our fledgling nation expanded its borders and its appetite for raw materials, it needed increasing quantities of resources and detailed delineations of geological environments. The Appalachian states focused on coal resources and Upper Paleozoic stratigraphy; southwest and midwest states stressed oil and gas geology; and western states worked on metallic mineral deposits and their origins.

The scope and functions of research in those early surveys were shaped by some of the great early pioneers in geological sciences, such as David Dale Owen, the first State Geologist of Indiana and second State Geologist of Kentucky; William W. Mather, Regional State Geologist in New York, and first State Geologist of Kentucky; Charles H. Hitchcock, second State Geologist of Maine; then there was Edward Hitchcock, first Director of Surveying in Massachusetts; Henry D. Rogers, first State Geologist of New Jersey and then first State Geologist of Pennsylvania, served as the source of a major theme on the geological framework; James Hall, first director of the Geological and Natural History Survey in New York and first State Geologist of Iowa; and many other distinguished geologist administrators. Among these was Morris Leighton who was a very pursuasive administrator for the Illinois Survey and was largely responsible for promoting the Illinois Survey to the largest and most productive state survey. It was productive not only in accomplishment but in budget and manpower as well.

The state surveys played an early role in studies of the relation between geology and our environment. Geology was an environmental science long before the term was popularized. Early in their history, the state surveys investigated the relation between geology and transportation routes, agricultural lands, ground-water supplies, earthquakes, and landslides. Gradually, the role of the state surveys in environmental matters has increased until today environmental matters are probably the major political justification for the surveys' continued existence. I am pleased to note that this same theme seems to be coming through in the remarks by the previous speakers, both of the provincial and of the other surveys. Our state surveys are involved in waste-disposal siting, geologic-hazards delineation, mined-land reclamation, radon mapping, powerplant siting, transportation routing, ground-water pollution mitigation, and land-use planning.

Throughout their history of responding to state needs, state survey geologists have worked far beyond the limits of practical applications. New York State provided the great paleontological research of James Hall. Henry Rogers of the Pennsylvania Survey initiated the unraveling of the structural complexities of the northern Appalachians. The works of I.C. White (of the West Virginia Survey) on the origin and nature of coal in the Appalachians are recognized as scientific classics. T.C. Chamberlain as head of the Wisconsin State Survey provided classical scientific analysis of that state's geology. W.H. Emmons and N.H. Winchell of Minnesota are recognized pioneers in minerals research.

Many others could be named to the list of major scientific achievers at the state surveys.

Fundamental to the programs of the state geological surveys is the recognition that detailed geologic mapping is the foundation for all geological research, be it scientific or applied. State surveys have recognized that with the evolution of geological principles and concepts, remapping and reinterpretation of previously mapped areas are necessary. State surveys have expressed concern in recent years over the withdrawal of geologists from the field into laboratories and the emphasis on "black box" geological methods, both in academia and in government agencies. With the leadership of the Association of American State Geologists, a concerted educational and political effort is being mounted to address the need for authorizing and funding detailed geologic mapping by the state surveys as well as the U.S. Geological Survey. I am pleased to report that as of two weeks ago, the National Geologic Mapping Act was passed by the United States Congress. The development of that Act was a joint effort between the Association of American State Geologists and the U.S. Geological Survey, with strong support from Dallas Peck for which we are greatly appreciative.

I shall not attempt to expound on the enormous geological bibliographies created by the state surveys, replete with scientific tomes, detailed geologic maps, mineral resources studies, and ground-water reports. Many of you no doubt have collections of those publications in your libraries.

In summary, the 50 state geological surveys constitute a dynamic, evolving geological community, proud to be functioning at the interface of scientific progress and public needs, and proud of their 168-year record of achievements.

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Theme I Discussion

H. A. Lee: I am a user of the geological work and I play a role in many of these things that you are speaking of. I quite often take the new technology, and I translate these into the ability to use them throughout the world. One of the things that I notice in the western world at the present time is the introduction of environment that has made a major change in the legislation. And the legislation has a major role on three main factors. We have to look at the product, the full product, we have to look at the marketing, and we have to look at the finances. If we change that product in midstream by changing legislation, it actually can destroy the product. One example is that we have at the present time very marked changes in terms of parks. We have to remember that by so doing we are dealing with something which is long-range, and that is we are certainly looking at something in terms of the mineral industry that is 15 years down the road before we can bring something into production. This means that just the simple wording of a park is under review or is being looked at. So 15 years down the road there is absolutely no use in any investment money whatsoever, and it also means that there is no future in terms of mineral exploration because we have to look at this long-term investment.

B.J. Skinner: One of the problems about which some of the greatest concerns have been expressed around the world has to do with soil erosion and soil degradation. Both of them have major economic impacts.

P.J. Cook: It's a source of regret to me that the BGS doesn't have an existing role in this area. In Europe I think it's the BGR that probably has the clearest role in soil surveys and that sort of thing. In the United Kingdom, for a long time this role was taken on by a well-known institute, the name of which I forget, in Rothamstead. The reason I forget it is that it's almost been abolished now, through the pressures of the marketplace and so on. It's a great pity. We need to do this. The only role we have is in the geochemistry of soils, almost as an appendage to the overall geochemical program. Regrettably at the moment BGS does not have any significant role in that area.

D. St-Onge: In France this role for soil degradation is assumed by the National Institute of Agronomy. We have some cooperation with this Institute. We are also playing a role in coastal erosion. The Oceanic Research Institute in France is involved in the coastline and there is also activity centred on soil degradation due to former industrial sites.

R. Rutland: There is an issue of conflict of interest as a result of commercialization, and another issue as to whether by being induced into commercialization, one is prevented from proceeding with programs which may be more in the national interest as illustrated by the question of soil degradation and land degradation. Are the models being set for the future going to inhibit research in the national interest?

P.J. Cook: The answer is probably yes. There can be an inhibition of strategic research. There's always the potential with a strategic program to say if there's six-month slippage or twelve-month slippage, it doesn't matter that much. What we're trying to do is avoid that by having a separation of tactical and strategic research so that we see the core program as no different from any contract program. The science program is essentially being done as a contract for the Department of Education and Science. It's no more but no less important than any tactical research.

Conflict of interest can be a real problem. The way that we do it is to set up a wall between the various operations so that we do not have flow of information. One of the things we say is that the BGS works to the highest professional standards and that means that you don't get that sort of flow of information. So there is a real concern that there is that conflict of interest. We will try and ensure it doesn't. I think that BRGM have a greater problem in that they take things further downstream. I personally think that governments and government organizations and quasi-government organizations should not be involved in actual exploration and they should not be involved in actual exploitation. And I think that prevents a much higher level of conflict of interest if you go on further down the line. But however I'll let Dr. Johan speak on that one.

Z. Johan: Well, that's absolutely true. I agree with this analysis that we have a conflict of interest, mainly in the mining fields. For example, you know now we have more and more scientific projects between different ccuntries of the EC. Many are starting to put forward projects concerning exploration methods. Due to the new regulations of the EC, this requires two industrial partners from two different EC countries. Then it's clear that there is a little bit of difficulty for the BRGM to have a good cooperation with RTZ. But I think that this will be solved in the near future. There is in fact great pressure on the French government that the mining part of the BGRM has to go out of the BGRM as a private mining company. I think that will solve this problem.

D. St-Onge: Mr. Johan, you said that the BRGM devoted, I think, nine million francs to support 60 PhD theses. Can you tell us a little bit more?

Z. Johan: We have 60 people doing PhD theses. The PhD thesis is four years, and we have 15 young people coming yearly for the thesis program.. We publish subjects which are within our research program. We select subjects which are published and sent to French universities. Then we select candidates. The selections are made by the chiefs of our scientific projects. We then sign a research agreement with the university. This agreement is very specific concerning the research results and the publication. That means we have some rights over the publication of the results. It's a common project. We financially support the scholarship and the scientific work. We can then select a very good level of young people.

Unidentified Speaker: How long has this program been going?

Z. Johan: I think about 20 years.

B.J. Skinner: A subject that hasn't been touched on very much - Art Socolow touched on it very briefly - is the role of the geological surveys, national or state, on educating taxpayers on the importance of stewardship, shall I say, of the earth. And I think we are best placed to do that. Could anyone comment on that.

P.J. Cook: We've looked at this and acknowledge that we've got a role in education. The difficulty in these hard times is to find funding. We have put some money into it. But the sort of money that's needed to do a proper job of it isn't there at the present time. BRGM actually are doing quite a good job, I think, of popularizing geology in the high schools and so on. In the case of the BGS we are looking at how we can better do this. I suspect many other organizations would like to have a much higher profile in the educational area but are having difficulties in funding. Maybe this is one of the areas where we can work together.

P.E. Playford: In western Australia there is an educational program conducted by the Chamber of Mines in association with the Geological Survey for the education of teachers. Overall it's involved several thousand, I think, teachers over the years, of taking them round through mining areas and giving lectures on relevant aspects of the mining and petroleum industries, because there's so little geology or earth resources matters taught in the schools. If you can get the teachers onside we believe that this is the best way to promote the industry within the school system.

R. Rutland: One way of addressing the issue of stewardship is in advice to the governments. The advice can be unsolicited. I think all geological surveys have fallen short of the mark in providing governments with good, convincing stories about policy actions that could be adopted on the basis of geoscience considerations. This doesn't involve large campaigns in the field of education because public education is a very large task. Educating the legislators or the administrators is a much easier task.

A. Morgan: I'm here partially as the representative of the Canadian Geoscience Council. I think the whole matter of education within the surveys is critical. It's totally unrecognized in many ways. The little booklet, *What on Earth?*, which describes some of the work of the Canadian Geological Survey in public awareness in science, is something which I think managers have to build in to the tasks assigned within the survey. Obviously not all officers are good communicators. But certainly I would just like to make an appeal to the people in this room to allow some of your officers to be able to interact with public education areas, both through the national societies and also on a one-to-one basis with local and regional school boards. It is something which is critical to the wellbeing of our profession as a whole.

R. Smith: Just a word of caution on creating public information outreach programs. We had a major review done of our survey by the Canadian Geoscience Council a number of years ago, and they recommended strongly that we start a program in this area. We did last year - in the core program - we added about $200,000 to the program. This year we faced a budget cut and it was imposed from the top down that this program was not relevant and could not be defended and we lost the money and we lost the personnel.

D. St. Onge: There's a lesson to be heard there about getting rid of personnel.

E.A. Babcock: To date much of this effort in Canada in the Geological Survey has been through professional organizations. One of the things that has discouraged it is that there's been a tradition of rewarding academic excellence rather than public outreach and also rather than working hand-in-hand with industry. That is changing, and at the departmental level. There is now a recognition that we have to do more to educate young Canadians particularly as to the role of the earth sciences in their lives and their communities. We in the survey will be doing more of it. One of the things that we will be getting within the next month is the ability to sell our products and have the money come back to us rather than to the Treasury Board. We are planning to develop a series of publications similar to BRGM's popular series, and make that sort of a self-financing activity. Another role that's very important for geological surveys, and we are very active in this area, is in training of students. In Canada, there's really no other place that a student can get a good grounding in field geology. Even though our budgets are shrinking we are endeavouring to maintain our annual employment of about between 250 and 350 summer assistants each year. I think this is another role all surveys should look at.

THEME II: RECONCILIATION OF RESOURCE DEVELOPMENT AND ENVIRONMENTAL PROTECTION

The changing role of a federal geological survey: the evolution of the U.S. Geological Survey from exploration surveys to earth science in the public service.

D.L. Peck

Discussion

The Changing Role of a Geological Survey: The Evolution of the United States Geological Survey from Exploration Surveys to Earth Science in the Public Service

D. L. Peck[1]

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Abstract

The U.S. Geological Survey (USGS) was established in 1879 by combining four exploration surveys formed to determine the geology and mineral and energy resources of the relatively unknown western territories. The Survey's role quickly evolved and expanded to include topographic mapping and water resource studies and then continued to change over the ensuing 100 years to meet the changing needs of the growing Nation. Changes included both the addition of new responsibilities such as marine geology and remote sensing and the splitting off of other, mostly resource management and regulatory functions, into new agencies such as the Bureaus of Reclamation and Mines and the Minerals Management Service. Changes reflected world and national events such as war, societal issues including concern for the environment, new technology, and the changes in capabilities and responsibilities of other federal agencies and of state and local organizations.

Today, the USGS provides a broad spectrum of earth science information to the United States Government and its people. In addition to conducting both traditional and innovative research and investigations of the geology and mineral resources of the country, the USGS role has broadened to include studies of geologic hazards, assessments and monitoring of the quality and quantity of the Nation's ground and surface water, production of basic topographic maps and digital spatial data for the Nation, and the archiving of large digital and analogue geological, geophysical, geochemical, hydrologic, and remotely sensed data. Our constituents include the American public, other federal agencies, Congress, state and local agencies, academia, industry, and the international community.

The authority and capabilities of many federal, state and local agencies have grown over the past several decades, and our relationship continues to change to focus more on research and information partnerships. The USGS responsibility will increasingly be to take the lead in promoting interagency coordination, establishing goals and standards, providing indices to available data, and defining research needs.

As the 21st century approaches, the USGS has several programs that will provide a focus for the next decade. These programs include research on global change, research on water quality, assessment of the quantity and quality of the Nation's ground and surface water, modernization of our

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mapping systems, building of national digital cartographic data bases, research on geologic hazards, and geologic mapping.

Using the Global Change Research program as an example, the USGS is presently conducting studies of climate and hydrologic systems, the carbon cycle, biogeochemistry, greenhouse gasses, volcanic emissions, gas hydrates, paleoclimate, sea-level change, permafrost dynamics, sea ice and glacier ice changes, and desertification. This is quite an evolution from the single resources-oriented focus of 1879. Rather than being an organization composed principally of geologists, the USGS has evolved into an integrated collection of geologists, geophysicists, hydrologists, oceanographers, paleoclimatologists, paleontologists, botanists, cartographers, geographers, engineers, mathematicians, biologists, chemists, physicists, environmental specialists, computer scientists, and data managers.

Clearly, the function of the USGS has and will continue to broaden in the future, with an ever-growing emphasis on environmental quality, the balanced management of Earth's resources, and the need to understand domestic and international earth science issues. Knowledge of domestic energy and mineral resources will continue to be important. However, as the USGS increasingly becomes an integral part of a global economy, the gathering of information about world resources will become a higher priority for the Survey. Our goal remains to provide unbiased earth science information in the public service. More and more, we will accomplish that goal through a combination of in-house expertise and partnerships with others.

Résumé

La United States Geological Survey *(USGS) a été formée, en 1879, par la fusion de quatre organismes d'exploration qui avaient été créés pour recenser la géologie et les ressources minérales et énergétiques des territoires, alors relativement inconnus, de l'Ouest. Le rôle de la USGS a évolué rapidement pour englober la cartographie topographique et l'étude des ressources hydriques, puis a continué de se modifier au cours des cent années suivantes pour satisfaire aux besoins changeants d'un pays en pleine croissance. Elle s'est vu confier de nouvelles responsabilités comme la géologie marine et la télédétection, mais en a cédé d'autres, en grande partie des fonctions de gestion et de réglementation des ressources, à de nouveaux organismes comme le* Bureau of Reclamation, *le* Bureau of Mines *et le* Minerals Management Service. *Ces changements sont survenus en réaction à des événements mondiaux et nationaux comme la guerre, à des préoccupations sociétales comme la sensibilisation à l'environnement et l'effet des nouvelles technologies, ainsi qu'à l'évolution des capacités et responsabilités d'autres organismes fédéraux et d'organisations d'état et locales.*

Aujourd'hui, l'USGS offre un vaste éventail de renseignements géoscientifiques au gouvernement des États-Unis et aux Américains. En plus de poursuivre des recherches et des études, tant traditionnelles que novatrices, sur la géologie et les ressources minérales du pays, l'USGS a élargi son rôle pour englober l'étude des risques géologiques, l'évaluation et la mesure qualitatives et quantitatives des eaux souterraines et superficielles du pays, la production de cartes topographiques de base et de données spatiales numériques, et l'archivage de vastes données géologiques, géophysiques, géochimiques, hydrologiques et de télédétection numériques et analogiques. Nos clients comprennent le public, d'autres organismes fédéraux, le Congrès, des organismes d'état et locaux, des universités, le secteur privé et la communauté internationale.

Les pouvoirs et les compétences de nombreux organismes fédéraux, d'état et locaux ont augmenté au cours des dernières décennies. Nos rapports avec ces organismes continuent d'évoluer pour se concentrer de plus en plus sur la collaboration dans le domaine de la recherche et de l'information. De plus en plus, notre rôle consistera à promouvoir la coordination entre les organismes, à établir des objectifs et des normes, à fournir des répertoires des données disponibles et à définir les besoins de recherche.

À la veille du XXI^e^ siècle, l'USGS poursuit plusieurs programmes qui orienteront ses activités des dix années à venir. Ces programmes comprennent les recherches sur le changement planétaire, les recherches sur la qualité des eaux, l'évaluation qualitative et quantitative des eaux souterraines et superficielles du pays, la modernisation de nos systèmes de cartographie, la constitution de bases

nationales de données cartographiques numériques, les recherches sur les risques géologiques et la cartographie géologique.

Dans le cadre du programme de recherche sur le changement planétaire, par exemple, l'USGS étudie le climat et les systèmes hydrologiques, le cycle du carbone, la biogéochimie, les gaz contribuant à l'effet de serre, les émanations volcaniques, les hydrates de gaz, les données paléoclimatiques, le changement du niveau de la mer, la dynamique du pergélisol, les changements de la glace de mer et de glacier, et la désertification. C'est dire que nous avons fait beaucoup de chemin depuis 1879, où toutes nos activités étaient axées sur les ressources. Au lieu d'être surtout composée de géologues, l'USGS regroupe aujourd'hui des géologues, des géophysiciens, des hydrologues, des océanographes, des paléoclimatologues, des paléontologues, des botanistes, des cartographes, des géographes, des ingénieurs, des mathématiciens, des biologistes, des chimistes, des physiciens, des spécialistes de l'environnement, des informaticiens et des gestionnaires des données.

Il est manifeste que la fonction de l'USGS, comme elle l'a fait déjà, continuera de s'élargir et de s'orienter de plus en plus vers la protection de l'environnement, la gestion judicieuse des ressources de la Terre et la nécessité de comprendre les grands dossiers géoscientifiques nationaux et internationaux. Il continuera d'être important de connaître les ressources énergétiques et minérales nationales, mais, plus l'USGS deviendra partie intégrante d'une économie mondiale, plus la collecte de données sur les ressources mondiales prendra de l'importance. Notre objectif reste le même: fournir des renseignements géoscientifiques impartiaux, au service du public. De plus en plus, nous réaliserons cet objectif en collaborant avec d'autres organismes, en plus d'avoir recours à nos propres compétences.

I am Dallas Peck, Director of the United States Geological Survey–the USGS–and it is my pleasure to be here today to participate in the celebration of the 150th anniversary of the Geological Survey of Canada and in this International Conference of Geological Surveys. I am pleased to have this opportunity to talk with you about the changing role of geological surveys in this time of increasing environmental awareness. My talk will focus on the future of our national geological surveys. To this end, I will discuss the evolution of the USGS from its early role of conducting exploration surveys to its present mission of providing earth-science information to serve the needs of the public. Many of your individual surveys have already experienced this change, and others of you will face it in the near future.

We are all concerned about the use of land, water, energy, and the mineral resources of the Earth. We must ensure an adequate supply of critical resources in the future without irreversibly altering our natural environment. Our response to this challenge and to many other critical questions about the future of our planet and its inhabitants depends on continually increasing our knowledge about the environment, structure, resources, and dynamics of Planet Earth. Providing the scientific information necessary to respond to these questions is the primary mission of my organization and of the other national geological surveys that you represent.

Such information is essential for the public and its officials so they can make informed decisions concerning the wise use of our nonrenewable resources. The same information is crucial for understanding the changing earth environment and for making decisions that affect our standard of living, economic growth, environmental future, and national security.

During the mid-19th century, the United States expanded rapidly to the west. Thousands of settlers journeyed into the uncharted western territories to establish farms, homesteads, ranches, and new communities. Before 1879, four exploration surveys, each tasked to determine the geology and the mineral and energy resources of part of the relatively unknown western territories, had provided virtually the only geographic and geologic information available for these areas.

On March 3, 1879, the United States Congress established the USGS to consolidate the western surveys. The USGS was tasked with conducting systematic and scientific "classification of the public lands, and examination of the geological structure, mineral resources, and products of the national domain." The Survey role quickly evolved and expanded to include topographic mapping and water resources studies. The USGS role has continued to change over the ensuing 113 years to meet the needs of the growing United States. For example, in 1888, the USGS began gaging the flow of the Nation's streams in order to determine the potential for irrigation in the arid western lands. Over the years, we have acquired new responsibilities. In 1962, Congress authorized us to examine the geology of the ocean floor. At other times, resource management and regulatory functions have been split from the USGS, resulting in new agencies such as the Bureau of Reclamation, the Bureau of Mines, and the Minerals Management Service.

Some changes have been in response to the advent of new technologies. We established an expertise in remote sensing following the development of aircraft and aerial photography and then broadened this expertise with the advent of satellites and space-borne earth scanners. Other changes reflected world and national events such as war, societal issues including concern for the environment, and changes in the capabilities and responsibilities of other federal agencies and of state and local organizations.

Today, the USGS provides a broad spectrum of earth-science information to the United States Government and its people. We conduct both traditional and innovative research and investigations of the geology and mineral resources of our Nation. The USGS role includes studies of geological hazards - such as earthquakes and volcanic eruptions. We assess and monitor the quality and quantity of the Nation's ground and surface water. We produce topographic maps and digital cartographic data for the Nation. We serve as an archive of large digital and analog earth-science data sets from the geophysical, geochemical, hydrologic, and remote-sensing disciplines. Our constituents include the American public, other federal agencies, Congress, state and local agencies, academia, industry, and the international community.

We have a staff of about 10,000 and a budget of $800 million, of which three-quarters is appropriated and one-quarter comes from other federal, state, and local agencies. We have over 200 offices; most of our people are in three main offices. The funding route is not "we-ask and it-is-given." We submit budget requests to the Department of the Interior and to the Office of Management and Budget and defend them before Congress. They are either signed or vetoed by the President. So we don't have complete control over our fate, as I'm sure none of you do, either.

The authority and capabilities of many federal, state, and local agencies have grown over the past several decades. Our relationship with these agencies continues to change in order to focus more on research partnerships and information sharing. USGS responsibilities will be to initiate and promote interagency coordination and partnerships, establish goals and standards, provide indices to available data, and define research needs. In other words, we can't do it all ourselves. More and more, we have to form partnerships with other organizations.

As the 21st century approaches, the USGS has several new and comprehensive programs that will provide a focus for the next decade. These programs include research on global change, assessment of the quantity and quality of the Nation's ground water and surface water, modernization of our topographic mapping systems, building of national digital cartographic data bases, geographic information system applications, research on geologic hazards, a renewed focus on geologic mapping, and study of the deep continental crust.

Many current and future issues of national and global concern will affect the programs of the USGS and other national geological surveys. The disposal of hazardous wastes, including radioactive wastes, will be a significant challenge. Understanding and mitigating the problem of pollution of ground and surface water by both point sources and nonpoint sources such as agricultural chemicals and urban runoff will require substantial efforts.

A better understanding of natural hazards such as earthquakes, volcanic eruptions, landslides, floods, and coastal erosion is necessary if we are to reduce the loss of lives and property. Quantified estimates of undiscovered energy and mineral resources are necessary for land-management decisions and for long-term national strategic plans.

Recently, we have become aware of the annual ozone loss over Antarctica and of decreasing ozone levels above the Northern Hemisphere. We are also measuring increased levels of greenhouse gases in the atmosphere. These discoveries and others have made people around the world aware of the dynamic and possibly fragile nature of the Earth. The effect of human activity on the Earth is also receiving substantial attention. In the United States, about a dozen science agencies, including the USGS, banded together to study global change and to form the United States Global Change Research Program.

For the past four years, I served as chairman of the Committee on Earth and Environmental Science, the body responsible for overseeing of the United States Global Change Research Program. The goal of the program is to establish the scientific basis for national and international policymaking related to natural and human-induced changes in the total earth system. This program serves as a good model for the future because it brings together scientists with specialities in many different disciplines, representing many agencies and countries, to attack problems that are of mutual concern!

The objectives of the United States Global Change Research Program are (1) to establish an integrated, comprehensive, long-term program of documenting the earth system on a global scale; (2) to conduct a program of focused studies to improve our understanding of the physical, geological, chemical, biological, and social processes that influence earth system processes and trends on global and regional scales; and (3) to develop integrated conceptual and predictive earth system models to guide formulation of public policy.

The USGS, as well as several other national geological surveys, is an active participant in this partnership to assess the Earth's dynamic systems. I suspect that, in the future, other national geological surveys may well be spending an increasing part of their efforts on this topic.

Under the United States Global Change Research Program, the USGS is presently conducting studies of climate and hydrologic systems, the carbon cycle, biogeochemistry, greenhouse gases, volcanic emissions, gas hydrates, paleoclimates, sea-level change, permafrost dynamics, sea ice, glacier dynamics, and desertification - quite an evolution from the resources-oriented focus of 1879.

Because of this program and others the USGS has evolved into an integrated body of geologists, hydrologists, geophysicists, oceanographers, paleoclimatologists, paleontologists, geomorphologists, botanists, cartographers, geographers, engineers, mathematicians, biologists, chemists, physicists, environmental specialists, and computer scientists.

In recent years, many of these scientists have shifted their research emphasis. While some scientists continue to focus on traditional energy, minerals, and mapping topics, others are now involved in questions related to environmental issues, such as waste disposal, water quality, and global change. I believe that the directions these USGS scientists are taking may be the same directions that scientists of your own geological organizations will take as we approach the 21st century. This dual role of combining traditional energy, minerals, and mapping pursuits with a new emphasis on issues related to our environment is the future of our geological surveys.

What is the nature of our profession? We study geology, hydrology, cartography, geography, chemistry, geophysics, and all the other scientific disciplines through which we are informed about the processes, products, and problems of the Earth. The key word in the last sentence is "informed"! We gather information about the Earth. We, as earth scientists, are the conduit through which this information is brought forth.

Perhaps one of the most important aspects of the evolution of the geological surveys of the future is how this information will be made available to others. In the past, the sole consumer of our geological information was the geological community. Today, we realize that the target of our efforts is much broader. Our primary customer is the public we serve. We have a product to promote - earth-science information - and we need to analyze carefully how we present this product to the public. For many years, the motto of the USGS has been "Earth Science in the Public Service!"

We are seeing a change in who our constituents are and what we provide to them. We are also seeing an acceleration of the trend toward a quantitative approach to the geological sciences. Development of large digital databases has accompanied the growing need for resources and awareness of the environment. This change does not mean that the role of the traditional field geologist has ended, however.

This trend toward increased quantification cannot be made at the expense of fundamental geological field studies. The field geologist, whether studying mineral deposits or monitoring our changing environment, still represents the most important first level of data gathering in the geological sciences. Without increased efforts in field-related studies, the geological sciences would rapidly lose touch with reality and with the needs of our science. The acquisition of these basic data must remain a high priority now and in the next century.

In addition to spending their days in the field with a hammer and a hand lens, field geologists will also spend their evenings and office hours with a personal computer and a variety of digital data bases. Since the early 1970's, increasingly sophisticated instruments, such as Landsat, airborne geophysical studies, seismic reflection systems, and automated chemical analyzers, have provided gigantic digital data sets pertaining to the Earth at flow rates of megabytes per second. New instruments aboard the proposed Earth Observing System (EOS) scheduled for launch near the end of this century, will provide a terabyte of data per day.

Sophisticated supercomputers are now routinely being used to trace seismic waves, simulate soluble transport in ground water and predict future climate. In fact, the general circulation models (GCM's) that are produced by these computers are the basis for our awareness and initial concern about global change. A substantial percentage of the funding of the United States Global Change Research Program is dedicated to managing the large volumes of Earth-related data that are now being produced.

An area of technical development that is becoming increasingly important is Geographic Information Systems or GIS. Since the first publication of modern geologic maps in the 1700's and early 1800's, maps of diverse types have become a standard means of communicating geologic information. As the geological sciences become more sophisticated, more and different types of maps have appeared. Traditional mapmaking methods are a terribly inefficient and ineffective way of compiling and displaying large and diverse data sets. Recent advances in technology enabling us to digitize, manipulate, and display spatially oriented data sets make it possible to layer and combine many large digital data sets. GIS are being used to display combinations of information at different scales, projections, and perspectives at a number of locations.

Now we can integrate and evaluate diverse types of data like never before to address a broad spectrum of important questions. Data management is not just a key ingredient of the United States Global Change Research Program - it is a key ingredient of all USGS activities and should be a key ingredient of all national geological survey programs.

The USGS now has a leading role in federal geographic data coordination. Consequently, earth-science and base-map information gathered by the USGS will become more readily available and find more widespread application within the US federal data community. In late 1990, the Office of Management and Budget prescribed the organization and integration of geographic-based information across the US federal government. Specifically, all geographic-based information, including base maps and geological, geophysical, and geochemical data, will be gathered and released in standard user and transfer formats for widespread use. The use of uniform standards ensures that all digital data can be readily used and shared by interested parties. The USGS is also developing a National Radiometric Age Data Base and a National Paleontological Data Base to provide easy access to these very important data.

The USGS has been designated as the lead agency for coordinating Federal activities related to spatial data and information about US fresh water resources. We are working closely with other Government agencies to identify requirements, develop standards, plan projects, share resources, transfer technology, and evaluate results. Through interagency cooperation, we improve communications, facilitate collaboration, and build consensus. Our partnerships are with other federal agencies, state and local governments, and the private sector.

I think it is a really important movement in the United States to place emphasis on spatially referenced data coordination between many different federal, states, country, and city organizations, to adhere to standards, to provide indices to data, and to coordinate a wealth of data. I refer not only to traditional earth-science data but also to land ownership data, cadastral data, geodetic data, vegetation data, census data- all the spatially referenced data needed to tackle the kinds of problems that society is faced with these days.

I want to thank you for your patience as you have indulged me and permitted me to reflect on the changing nature of national geological surveys. Perhaps the most dramatic change is that we are all sitting together in this one room addressing international and global questions of mutual interest.

Clearly, the function of the USGS has broadened and will continue to broaden in the future. We will see an ever-growing emphasis on environmental quality, balanced management of Earth's resources, and a better understanding of international earth-science issues. Developing better knowledge of domestic land, water, energy and mineral resources will continue to be an important function. Because the United States is an integral part of the global economy, the gathering of information about world resources and the global environment is also an important priority for the USGS. Our goal remains to provide unbiased earth-science information in the public service. More and more, we will accomplish this goal through a combination of in-house expertise and partnerships with others.

What I have said about the USGS may well be directly applicable to your own geological surveys. We are all part of the increasing interdependence among nations. In the last year, many political barriers have disappeared, and we have seen our world become smaller. We are truly members of the global community. None of our countries are completely self-sufficient with respect to energy and mineral needs. In one way or another, we are all dependent on one another. Therefore, the importance of global resource and environmental issues to the future of each of our geological surveys becomes much greater. Together, as partners in the global community, we can answer these questions and meet the challenges of the 21st century.

Theme II Discussion

A.J. Naldrett: I would like to pick up on your emphasis on global affairs. We all agree that green is good and brown is bad, but the greener we want to be when it comes to the resource industries, which of course is where your survey started, where our survey started, the higher the costs are for mining and mineral processing. We live in a capitalist society where our ethic is maximizing return on the dollar. So it is completely logical and consistent with our ethics that our money goes where the return is greatest. Ontario mining companies spend an extremely small proportion of their exploration dollar in Ontario. Some of it comes to Quebec because it's a little bit easier there. Most of it goes out of the country, a large amount to Chile. Is green in North America good when it means brown in South America? We've already seen in preparation for Rio '92 that while the developing countries are willing to accept our development dollars they are not willing to accept our environmental constraints. Your job of course is to give advice to your government and sometimes the advice has to be the advice they don't want. What advice would you give on this question.

D.L. Peck: Whatever advice I give, I give it very carefully. My government has a posture in this whole area. There have been a number of frank internal discussions. With care I can speak my own mind. My position as far as the talk was concerned was that it is a global economy and it's a global earth system and we're going to have to adjust to that. And I don't think it's my role to say whether various shades of green or various shades of brown in this country or other countries are appropriate. One of our roles is to develop a better understanding of processes and a better understanding of the geology, to maximize investment in exploration. We must also develop an understanding of the processes of pollution resulting from mining so that we can expeditiously minimize that, depending on the policies of the country in which the operation takes place. As far as advice on policies, I've been Director for over 10 years and I've had four Secretaries of the Interior. I started off with Secretary Jim Watt. One likes to go down and brag about new things in Earth Science. I was showing him some shuttle radar that looked through the sands of the Egyptian desert into the paleo-valleys and it reflected the ancient climate of Egypt. I was commenting on this way to look into the past when he said, that was all very interesting but since the earth was formed 6,000 years ago, he didn't know how relevant it was. I'm afraid to say I shut up.

G.O. Kesse: BRGM helps developing countries quite a bit. We have had some very good relations with BGRM. I wonder why USGS has maybe not been assisting the developing countries as much. What are your plans for the developing countries.

D.L. Peck: Tom Ovenshine, Head of our office of International Geology is here, so he can speak in more detail. Our direct funding comes from the Interior through the Department of Interior through the Interior Appropriation Committee in 50 line items, none of which is aid to developing countries, all of which is approved by congressmen from states in the US and is by and large for studies in the US, augmented by studies around the world if those studies help studies in the US. So there is some emphasis on studying earthquakes abroad because then we learn better how to minimize the effects of earthquakes in the US. Our activities overseas are funded by such entities as the World Bank, and individual countries such as Saudi Arabia, and Venezuela by AID (Agency for International Development). Back in the 50's and 60's we had a very large international program, and we are very proud to say we helped get started the Geological Surveys of Chile, and Peru and Brazil and Liberia. Come the Green Revolution and the focus by AID was on farming and botany and growing better rice and they radically decreased their funding for mineral resource programs. And since then we have cut those programs because we have no funds to pay for those programs, in spite of searching for those funds.

U.G. Cordani: I will speak not as a president of IUGS but as a geoscientist from Brazil, a third world country. We all agree that green is good and everybody is talking about environment. That is why we are going to have the Rio '92 conference on environment and development. Tony Naldrett spoke about the economic aspect of mineral exploration. Because mineral exploration is becoming costly in North America, and because of the environmental costs associated with it, there is a shift and many multinationals and governments explore in third world countries. Third world countries don't want to bear the cost of that exploration because their priorities are quite different. Famine and survival are very different problems than in a developed society. But when you look at the overall system then you see that the environment will be more stressed by the operations in the third world country on a global scale. So what is the answer? I mean we are among geologists and we know the problems. How could geologists operate in a way to avoid this? How can we make use of Rio'92. What kind of advice can the big surveys give?

P.J. Cook: How many people here will actually be involved in the Rio de Janeiro conference in 1992? One, two, three, four. Very few people from the geosciences are involved.

Dr. Peck has a particular responsibility, which he probably doesn't want to shoulder because in the US there is a geologist heading up the Global Environmental Change Program. Few if any countries have a geologist in that position. We must recognize that the Earth Sciences are the starting point for much of the Global Environmental Change programs. Yet that message really isn't getting through. So Dallas, go for it, you're the flag bearer, I think, in this particular area, not only for the United States but I think for the Earth Sciences at the global level, which is a bit of a daunting prospect for you.

E. A. Babcock: At great risk I will answer this question from the standpoint of the Canadian mining industry. This is based on a very extensive survey that the Mineral Policy Department has done of the Canadian industry. And what the Canadian mining industry, which is huge, is telling them is that they will be as good environmentalists in less developed countries as they will be in Canada. They are not out to sort of loot and pillage, and the reason they are not exploring in Canada right now is because Canada has this overwhelming series of overlapping jurisdictions relating to the environment. There's a lack of clarity of permitting, a great deal of the land is tied up in native land claims and proposed parks, and it takes so long to get the permission to develop a mine that it's better to go to a country where they feel they are more welcome and they can do this in a shorter period of time. So it's not that they're escaping being good environmentalists but that we've managed to create a system that's overly bureaucratic.

D.L. Peck: After four years of beating my head against a stone wall, I retired from being Chairman of that effort on global change. I think in this program and lots of others we need to start paying less attention to the boundaries between our narrow disciplines. I noticed some facile talk sometimes using the word geologist, sometimes using the word scientist, and sometimes meaning solid-earth scientist, and I thought it reflected too narrow a viewpoint. Earth includes the oceans, the atmosphere, and the water running down the stream or through the rocks underneath. It really involves a partnership across these disciplines to understand what is going on. Sometimes meteorologists can be as narrow-minded as geologists. Sometimes they don't really show much appreciation for paleo-climate and the fact that honest-to-God we can test their computer models and maybe find them wrong, but we have a broad view. All we need to do is convince them to buy in.

B.J. Skinner: I disagree with Peter Cook at my peril. I'm going to remind you that there was a major PrepCon brought together by the International Council of Scientific Unions. It met twice for long periods in Vienna this last summer, and the results of that will be out in a book published by Cambridge University Press in May of this year. It was a scientific preparation for Rio '92 A large number of geologists, hydrologists, many well known people are involved. Fully one half of the papers are geologically based. So we haven't really been left out. But we haven't really done great service to our profession either. You'll be able to read in GSA Today, either in the next issue or the subsequent one, an article written by four or five of those geologists (two or three of us who wrote that article are here today - I'm one, Umberto Cordani's one, and Digby McLaren's one). We had to conclude that though the papers themselves clearly outline the problems, definitely say what the problems are, (in fact the evidence is perfectly clear what the problems are, we don't need more evidence, we know what the problems are and you do), we're not able as a group to stand up and say, we do know it and this is what we should do. We were one of the groups, like the rest, who in the long run equivocated. We said we need more research.

THEME III: RESOURCES FOR SOCIETY (TOWARDS THE TWENTY-FIRST CENTURY)

Changing resources in societies: metals towards materials, fossil fuels towards renewables - a changing role for geological surveys?

M. Kürsten and F.W. Wellmer

Advanced Materials: Status and development trends

H. Czichos

Discussion

Changing Resources in Societies: Metals towards New Materials, Fossil Fuel towards Renewables. A Changing Role for Geological Surveys?

F.-W. Wellmer[1] & M. Kürsten[2]

Wellmer, F.W. and Kürsten, M., Changing Resources in Societies: Metals towards New Materials, Fossil Fuel towards Renewables. A Changing Role for Geological Surveys; in National Geological Surveys in the 21st Century, Bouchard, D.S. et al. (compilers), Geological Survey of Canada, Bulletin 446, p.73-87, 1993

Abstract

Modern societies depend more and more on an ever increasing number of new materials such as alloys, ceramics, polymers, compounds with better properties. Such new materials, however, represent only the tip of the "pyramid of materials" necessary for the well-being of a nation. Basically a nation still needs the classical mineral and energy resources.

As far as value is concerned the foundation of the pyramid still rests on fossil fuels, with regard to tonnage consumed on construction materials. But new materials make most evident the growing importance of inventiveness and know-how in the intelligent use of both new and old materials. We find this fact reflected in the stagnant or even decreasing intensity of use factors (unit material consumed divided by unit gross national product (GNP)) for classical materials, and in the energy field in the decoupling of growth of GNP and energy consumption.

In highly developed countries like Germany not only the service sector and industries like the electronic and chemical branches show above average growth but also the non-ferrous metal manufacturing industry. Despite new materials available, substitution, and increasing political pressure to recycle materials as much as possible, growth rates for most primary raw materials still remain positive, though often small. This is a challenge to earth scientists to find the new resources for the future. Earth scientists must take a global view, following materials in their life cycle from source to end use. They must consider total material flow systems, including waste from exploitation and processing in order to minimize material loss and environmental impact. Equally, such a global view is required because of the increasingly higher quality standards in raw materials asked for by the processors due to environmental guidelines and in attempting to provide the right quality of the final product to be consumed by modern societies.

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Résumé

La société moderne dépend de plus en plus d'un nombre toujours croissant de nouveaux matériaux: alliages, céramiques, polymères et composés aux propriétés améliorées. Ces nouveaux matériaux ne représentent toutefois que le sommet de la «pyramide de matériaux» nécessaire au bien-être d'un pays. En fin de compte, un pays continue d'avoir besoin des ressources minérales et énergétiques traditionnelles.

Du point de vue de la valeur, la base de la pyramide repose encore sur les combustibles fossiles, dont d'énormes volumes servent à fabriquer des matériaux de construction. Mais les nouveaux matériaux montrent clairement l'importance croissante de l'innovation et du savoir-faire dans l'emploi intelligent de matériaux, tant nouveaux que traditionnels. Cela est corroboré par la stagnation ou même la baisse des facteurs d'intensité d'utilisation (unité de matériau utilisée, divisée par le produit national brut (PNB) unitaire), dans le cas des matériaux traditionnels, et, dans le secteur de l'énergie, par le découplage de la croissance du PNB et de la consommation d'énergie.

Dans les pays très développés comme l'Allemagne, il n'y a pas que le secteur tertiaire et des industries comme l'électronique et l'industrie chimique à connaître une croissance supérieure à la moyenne; le secteur de la fabrication des métaux non ferreux en connaît une, lui aussi. Malgré la disponibilité de nouveaux matériaux, la substitution et les pressions politiques qui poussent de plus en plus au recyclage maximal des matériaux, la demande de la plupart des matériaux primaires continue d'augmenter, même si ce n'est pas de beaucoup. Cela veut dire que les spécialistes des sciences de la Terre doivent trouver de nouvelles ressources pour l'avenir. Ils doivent voir les choses dans une optique plus large, notamment en suivant le cycle de vie complet des matériaux et en considérant l'ensemble des étapes, y compris les rebuts d'exploitation et de traitement, afin de minimiser le gaspillage des matériaux et la pollution de l'environnement. Cette optique est d'autant plus nécessaire que les transformateurs exigent des matériaux bruts d'une qualité toujours plus élevée, tant pour des raisons environnementales que parce qu'ils désirent fournir un produit final de qualité aux consommateurs de notre société moderne.

Thank you very much Mr Chairman. Before beginning, I would like to congratulate in the name of BGR the 150th Anniversary of the Geological Survey of Canada. We're proud of many years of very good and trustful cooperation between the two surveys, the German and the Canadian one. I trust that this will continue to be so in the future.

My talk deals with the changing resources in societies. Figure 1 shows examples of the bell-shaped life-time production curves of mining production centres which have been used by Skinner to construct a quantity-time diagram showing the traditional stages in mine development, exports, and imports in industrialized countries. (Figure 2)

Figure 1: Examples of lifetime production curves

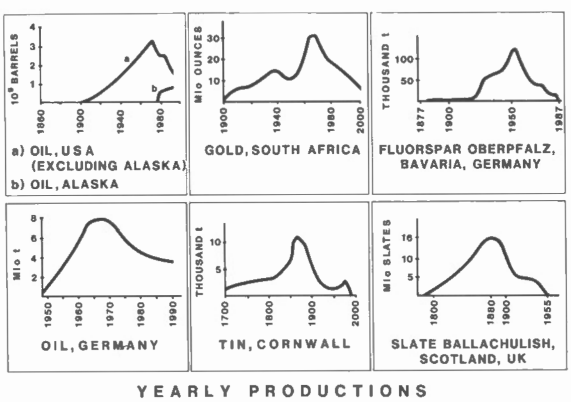
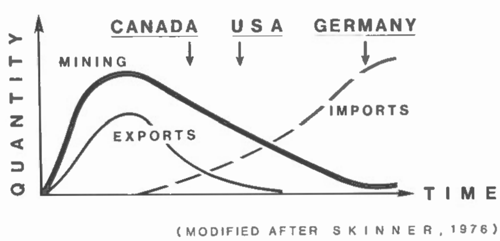


Figure 2: Stages in mining, exports and imports of an industralized country (modified after Skinner, 1976 and Hewett, 1929)



Canada is a prime example of a mining and raw material exporting country, and thus lies in an enviable position on the left side of the diagram of Figure 2. We in Germany have now reached the end of the metal mining cycle with the closure of the two last metal mines just two weeks ago. The Bad Grund lead/zinc vein mine in the Hartz mountains and the famous Meggen Mine which exploited a Sedex type lead/zinc deposit. As a consequence Germany is now 100% import-dependent for all metals as far as primary sources are concerned. Nevertheless Germany can still be regarded as a mining country but only with respect to potash, lignite (Germany is in fact the largest lignite producing country in the world), coal, fluorite, barite and graphite.

I want to use Skinner's graph (Figure 2) to show how the role of a geological survey changes in relation to national trends in mine development, exports and imports. I shall return to this diagram later and I shall at first be dealing with the demand side of the mineral resources market, then with the supply situation and in my conclusion I want to stress the changing roles of geological surveys.

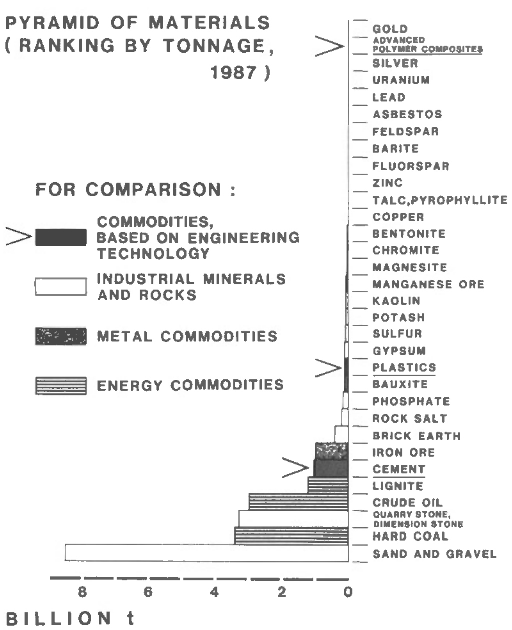
To begin with, new materials exert an influence on demand patterns which one cannot afford to ignore. The welfare of modern society depends more and more on an ever increasing number of new materials such as alloys, ceramics, polymers, and composites with continually improved properties. In industrialized nations, companies typically spend about 3-8% of sales on research, not only on new products but also on new materials. There is a constant process of competition and substitution between materials of all kinds.

Modern society is certainly fascinated by new materials: these include superconducting and hard magnetic materials, ceramics such as those used in the heat shield of the space shuttle to protect it on reentry, which have such a low heat conductivity that you can hold a hot ceramic tile between your fingers without being burned, advanced polymer composites as used in the Stealth aircraft because they are invisible to radar, and more down-to-earth glass fiber which replaces copper wire in cables. Whoever wins this year's America's Cup sailing race off San Diego, USA, whether it is a yacht from the defender nation, the USA, or a yacht from a challenger nation, the winning boat will certainly be made of the most advanced polymer composites. In contrast we read bleak reports in the newspapers of production centres for the traditional metals closing down: decaying towns around derelict steel mills, or shipyards threatened by closure, as at present in the eastern part of Germany. But in a sense, these are only individual cases and it is dangerous to draw conclusions prematurely about the future of the traditional raw materials without hard statistical facts. It is best to be systematic and start with those facts which are relevant to the task of geological surveys.

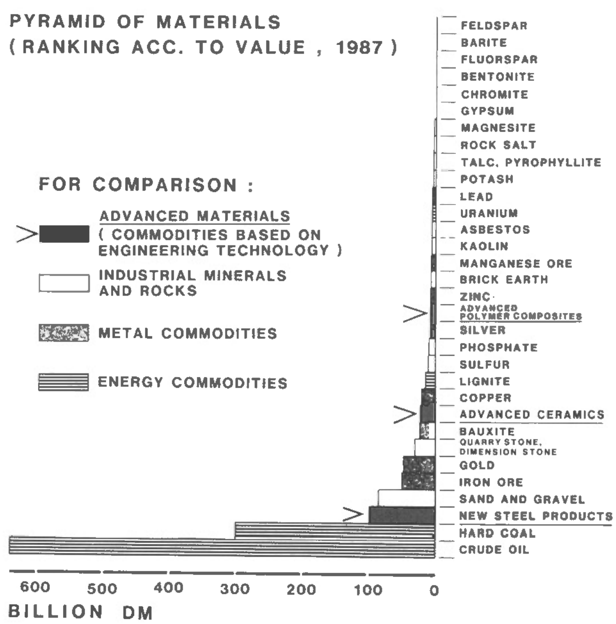
THE MATERIALS PYRAMID AND GROWTH RATES

One can present the statistics of the global minerals in the form of a pyramid. The pyramid can be viewed in terms of value, tonnage, or volume. The base of the value pyramid still comprises the fossil fuels and the base of the tonnage pyramid the construction raw materials (Figures

Figure 3: Materials pyramid based on tonnage (3a) and value (3b), reference year 1987 (sources: Ceramic Industry Staff Report, 1991; Czichos, 1988; Lawatschek, 1990; Glenz, 1989; Sorrell, 1989)



3a



3b

3a and 3b). These pyramids reflect certain basic needs of mankind: people have to be housed, houses have to be heated, and people and goods have to be transported. In future these basic needs may be met more efficiently - an aspect to be discussed later - but in principle man's basic needs will not change.

I have added some new materials in the value pyramid, such as advanced polymers, advanced ceramics and new steel products, which, of course, are made out of the primary materials in the pyramid. (Figure 3a) The graph in Figure 3b puts the value of these materials in perspective with respect to the traditional raw materials.

Next we turn to growth rates. Many people are fascinated by the growth rate of new modern materials. Whereas growth rates of metals currently vary between 0.5 to 3.0%/a, for new materials they are as high as 20%/a in some cases. These high growth rates, however, should be looked at in perspective.

In a tonnage-time graph the amount of most materials consumed over the years normally gives an S-shape. At first consumption rises slowly, then the curve steepens (the growth stage), and finally it flattens out again (the maturity stage). This is shown taking aluminium (Figure 4, top) as an example.

In practice, of course, consumption curves are not smooth curves but show fluctuations due to economic booms and recessions. If one now plots the growth rates averaged over 5-year periods against time, one obtains the curve in Figure 4, bottom. For aluminium one can see how the growth rate becomes smaller as consumption increases and the maturity stage is approached. The decline of the growth rate is a mathematical necessity. Consequently, a high growth rate of a new material is to a large extent a function of the age and maturity of the material as a commodity. This is supported by Figure 5, in which growth rates of new materials are plotted against sales. A definite trend can be recognised.

Figure 4: Aluminium: annual world consumption (top) and growth rates averaged for 5-year periods (bottom)

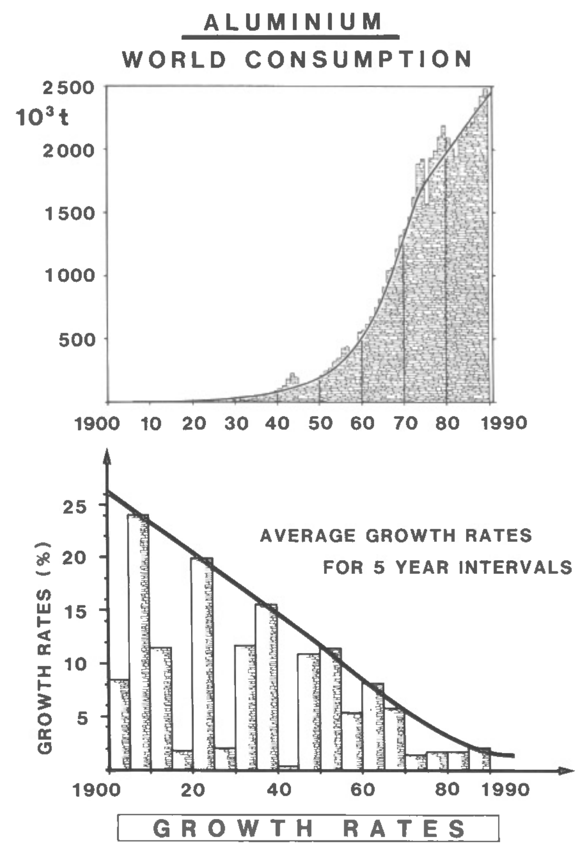
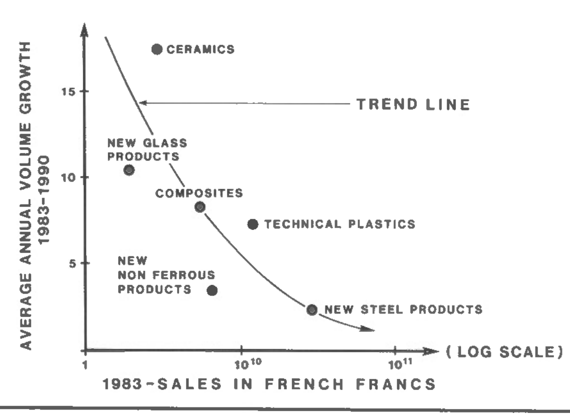


Figure 5: World-wide annual average growth rates of new materials in percent for the period 1983 to 1990 in relation to worldwide sales of new materials, in French francs (source: Bureau d'Informations et la Pre`visionsEconomiques, 1986)



DEMAND SIDE OF THE MINERAL COMMODITY MARKET

Consumption Trends and Industrial Structure

We shall now consider the demand side of the mineral commodity market, particularly from the viewpoint of industrial structure. We shall be mainly using data from Germany as, in our opinion, Germany is representative of many of the industralized nations, which, despite some accelerated growth in some newly industrialized countries (NICs), still consume 75 to 85% of all raw material produced globally.

It is a fairly common notion that, in countries like Germany in which the price of energy is high, the growth of the gross national product (GNP) has been decoupled from the growth of primary energy and total metal consumption since the oil crises in the 1970's.

It is worthwhile, however, examining this notion in detail. Total metal consumption is almost completely dominated by steel consumption. However, if one ignores steel it becomes obvious that base-metal consumption in Germany grows more or less parallel to the trend of the GNP (Figure 6). In addition, if we do not consider total primary energy but only electricity, we again see a parallel trend to the GNP.

We interpret the graph in Figure 6 as follows: The more intelligent use one can make of a raw material or a form of energy, the more it will be coupled with the growth of the GNP.

To corroborate this interpretation we can look at man's favourite toy: the CAR. Figure 7 shows a projection of the materials used in middle and upper class cars in 1996 in comparison to those actually used in 1986. These projections are from a study by the research centre of Mercedes, a German car manufacturer (Razim & Kanuit, 1989). Figure 7 reveals a decrease of the content of steel and iron and an increase in the contents of all other materials that are light-weight, metals and plastics alike. There is immense pressure to produce cars which can be easily recycled. German car manufacturers are now giving a take-back guarantee for each car at the end of its lifetime and Germany is at the brink of introducing a kind of waste tax or duty to force companies to recycle as much as possible.

Figure 6: Relative trends of gross national product (GNP), and the consumption of steel, base metals, primary energy, and electricity in the Federal Republic of Germany between 1970 and 1990 (source: VIK, 1991; IISI, 1991; Metallgesellschaft AG)

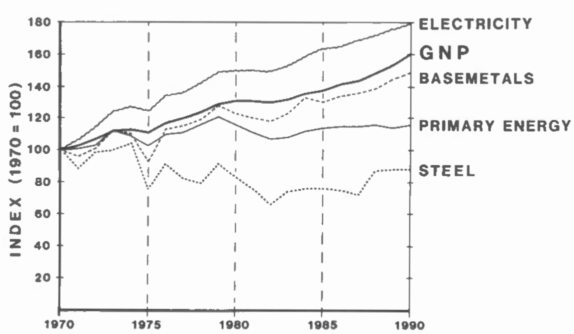
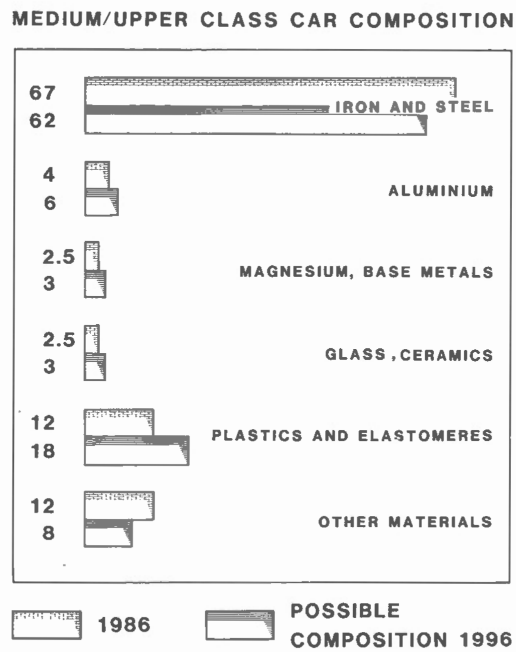


Figure 7: Comparison of materials composition of medium/upper class car 1986 and 1996 (source: Razim & Kaniut, 1989)



Looking at steel in cars in more detail, it is worth taking US statistics (Table 1). If one does not consider all the steel used in cars but only the more advanced types of stainless steel and HSLA steel (high-strength, low-alloy), one does in fact see positive growth rates, and thus our previous interpretation is substantiated. The more intelligent use one can make of a raw material or form of energy, the more it will be coupled with the growth of the Gross National Product. (Figure 6)

Table 1: Light Vehicle Production (USA) Annual Growth of Advanced Materials

	% annual growth	
Material	1977-1989	1989-1994 (projected)
HSLA steel	5.4	3.4
Stainless steel	2.1	2.8
Aluminium	4.1	4.2
Magnesium	-	12.3
Powdered metal	6.3	6.6
Engineered Plastics	10.9	8.7
Thermoplastic elastomer	6.6	9.8
Advanced ceramics	-	49.6

(Source: American Metal Market, 4.4.1990)

Further support for this interpretation yields an analysis of the German industrial structure. Figure 8 shows the average growth rates of certain sectors of German industry. They are plotted for the period 1970 to 1980 on the x-axis and for the period 1981 to 1989 (the latest available figure) on the y-axis. The field between the x and y axes can be divided by dashed lines into growing and shrinking sectors, meaning growth rates above and below zero. More interesting, however, are the solid lines: the average growth rates for the respective period for all sectors. Since we had a recession in the first half of the eighties, which triggered considerable rationalisation, it might be premature and unfair to draw conclusions about the future just by comparing the performance of the seventies with that of the eighties.

We might be on firmer ground if we compare the growth rates in the first quadrant (I), hatched in Figure 8 and including all sectors of industry underperforming in the seventies and eighties, with those in all the other quadrants (II, III and IV), i.e. with the industrial sectors that overperformed in at least one decade if not both.

The following general conclusions can be drawn from Figure 8:

1.) The primary sectors with the exception of electricity generation are shrinking. This is especially true for the mining industry.

2.) The manufacturing industry reveals a mixed picture. Some sectors are underperforming (leather, textiles etc.), others are overperforming. The fastest growing industries, namely plastics, computer and office machine industries, belong to this group.

3.) The tertiary sector, the services industry, showed more or less continuous growth.

In the case of industries which consume metals, the traditional smoke-stack industries like steel making foundries, as well as the ship-building industry, show a declining performance. Other metal consuming industries, however, like the electrical and vehicle industries, and of course the aerospace industry, but also the industry sectors for semifinished steel and for base-metal products, plot in those quadrants indicating above-average growth in at least one of the periods considered. Growth in the base-metal manufacturing industry was above average in the sixties and seventies, but the industry showed a decline in 1988 and 1989. This industry is typically a medium size industry, very flexible and innovative in finding market niches and producing new "intelligent" products.

Raw Material Consumption

For representatives of producing nations like that of our Canadian hosts, it is of course of interest to learn how the industrial development of a consuming nation translates into metal consumption.

The high political pressure in Germany to recycle as much as possible has been mentioned before. The ratio of primary to secondary materials is of interest. Therefore, you will certainly want to know how much of the increase in consumption will be applied from primary sources and how much from secondary sources. It is obvious that the supply from secondary sources has risen in recent years but an increasing amount of material was, and still is, supplied from primary sources. All the curves in Figures 9a and 9b show primary, secondary and total.

Figure 8: Average growth rates of sectors of the German economy for the period 1981 to 1989 in relation to growth rates for the period 1970 to 1980 (source: Federal Office for Statistics, growth rates for periods 1970 to 1980 and 981 to 1989 interpolated, giving growth rates of each year equal weight (see Wellmer, 1989)). Fields I-IV explained in text.

Primary production
1. agriculture, forestry
2. leather
3. crude oil processing
4. wood processing
5. building industry
6. tobacco industry
7. food industry
8. garment industry
9. renovations,extensions (building)
10. textiles
11. musical instruments, toys
12. paper + cardboard processing
13. printing
14. rubber
15. wood
16. cellulose and paper processing
17. chemical industry
18. precision mechanics, optical ind.
19. china ware, industrial ceramics

Services

20 traffic
21 private households
22 insurance
23 social insurance
24 real estate agencies
25 banking
26 postal services
27 trading
28 municipal services

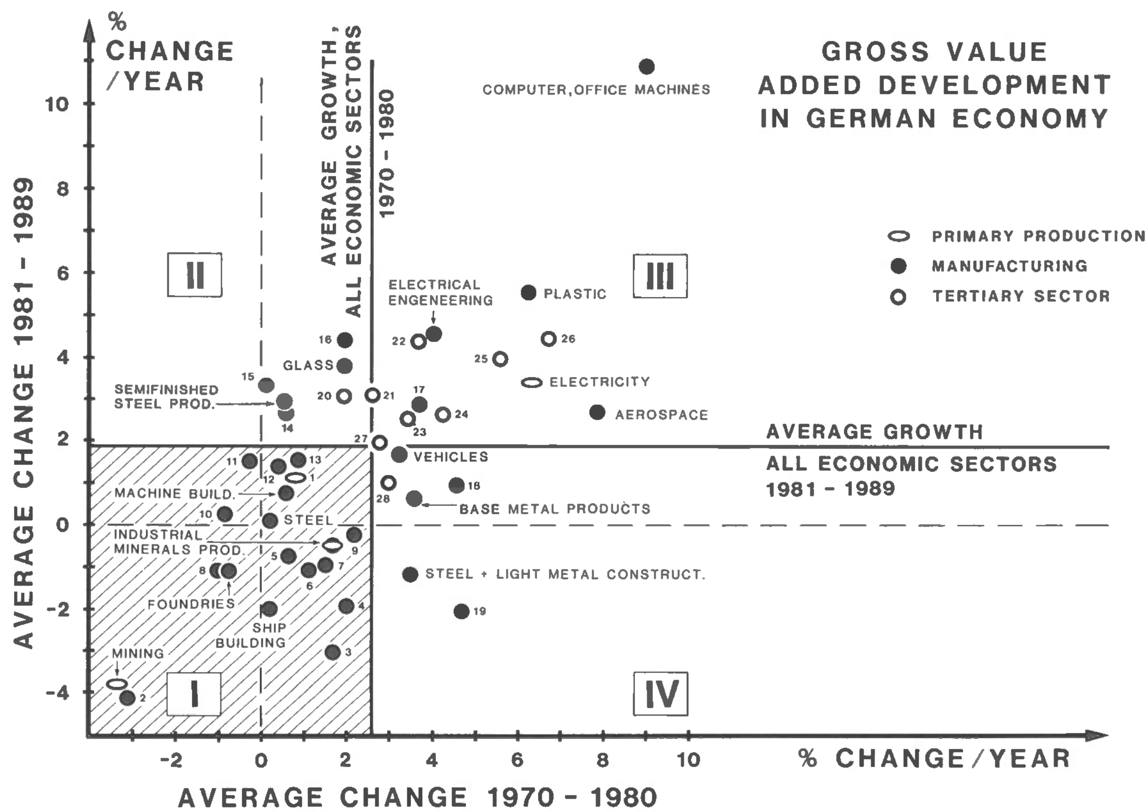
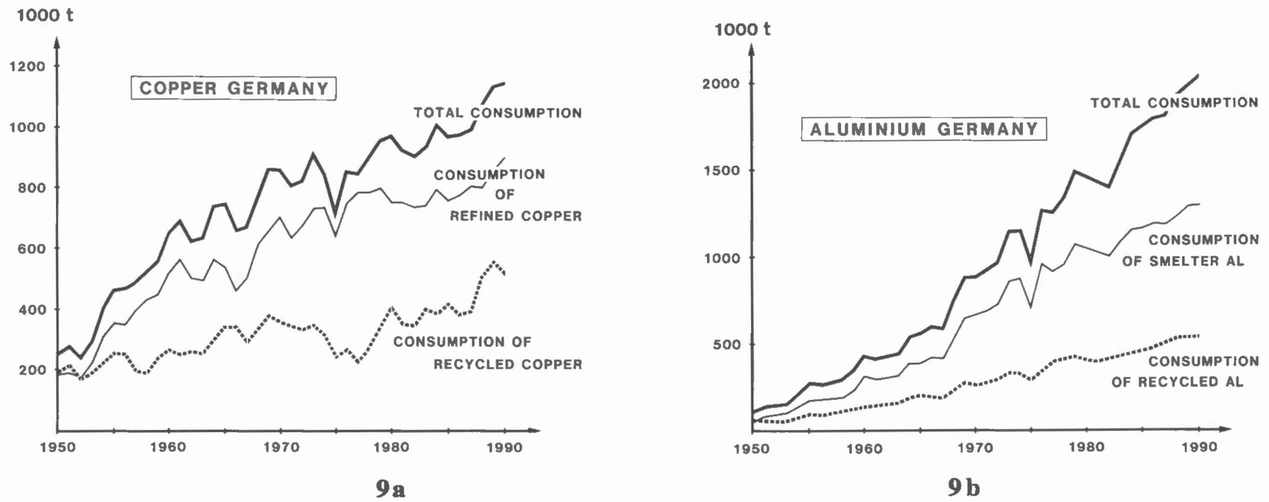


Figure 9: Consumption of primary and secondary copper (a) and aluminium (b) in the Federal Republic of Germany between 1950 and 1990 (source: Metallgesellschaft AG)



Before moving to the supply side, it is necessary to provide some statistical back-up to show that it is justified to take Germany as representative of many of the industrialized nations. One could present various statistics but I have taken the intensity-of-use factor; which means the ratio of unit of metal consumed to unit of gross national product. One sees in Figures 10a and 10b the typical bell-shaped curve: an increase of the IOU factor with increasing GNP from underdeveloped nations to newly industrialized countries (NICs) and then a decrease of these factors towards the fully industrialized nations. In both cases for steel and copper, Germany plots fairly well in the field of the highly industrialized countries.

SUPPLY SIDE OF THE MINERAL COMMODITY MARKET

The Resource/Reserve Base

One of the chief tasks of geological surveys, particularly those of producer nations, is to be active in the forefront of the minerals industry. They supply industry with basic geological, geophysical and geochemical data, and also develop concepts as to where to find the new generation of ore deposits that host the future mineral supply.

This raises the question of the resource base of a commodity. The proportion of the resource base that can be converted by exploration work and development into reserves in the near future fluctuates considerably. Conversion of the resource base into reserves is positively or negatively influenced chiefly by these factors:

a) commodity price trends
b) exploitation cost trends
c) technological innovations
d) environmental restrictions in the producer country, but also in the consumer countries.

Let me briefly comment on these four major influences.

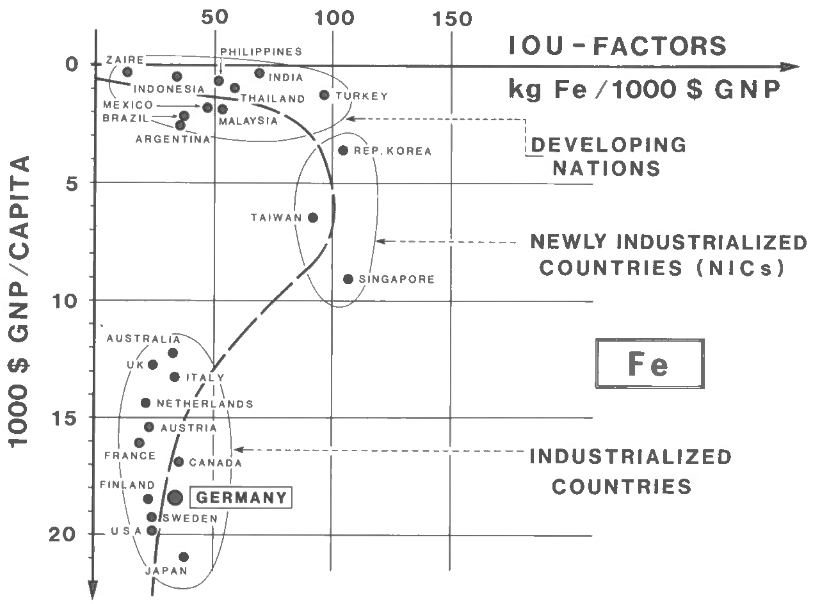
Commodity prices

Every member of the mining community is aware of the severe impact of metal prices on the mineability of ore deposits. The two price graphs (Figures 11a and b) demonstrate that most commodity prices have not risen in real terms practically throughout the whole century.

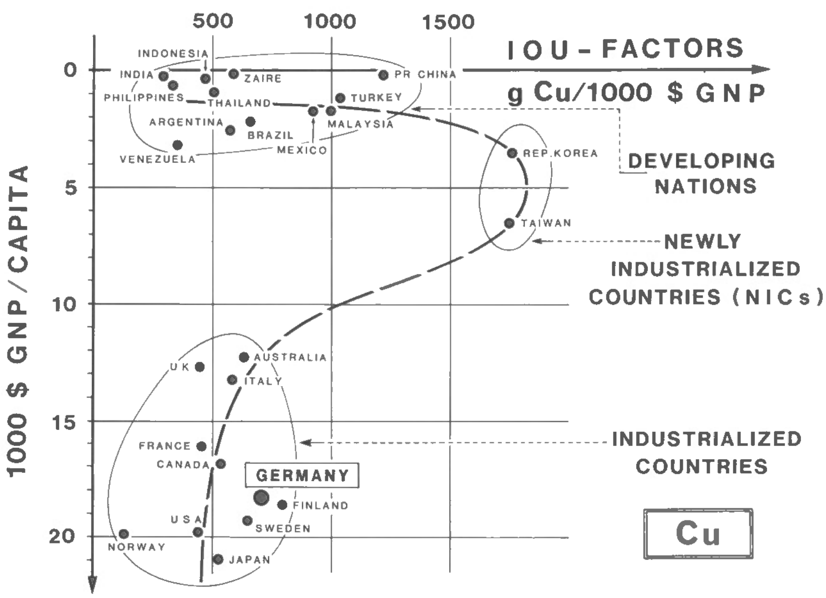
Exploitation costs

Today, most mining companies operating in market economies will only invest in major new mining ventures if these deposits fall into the lower third of the cost frequency curve (lower third rule, Wellmer, 1989). This results in a constant pressure to rationalize, and pushes other producers to the higher cost end of the cost curve. Figure 12 is a graph modified from Giegerich's paper on The Red Dog Development in Alaska and shows the first year of production of the chief zinc producers. The trend is obvious that older production centres are pushed to the higher cost end. There are of course other influences contributing to this effect, such as the depletion of richer parts of the deposits and the pressure to mine lower grades to extend the lifetime of the mines.

Figure10: Worldwide comparison of use factors (IOU) for steel (a) and copper (b). Reference year 1988 (sources: IISI,1991; Metallgesellschaft AG, World Bank, 1989)

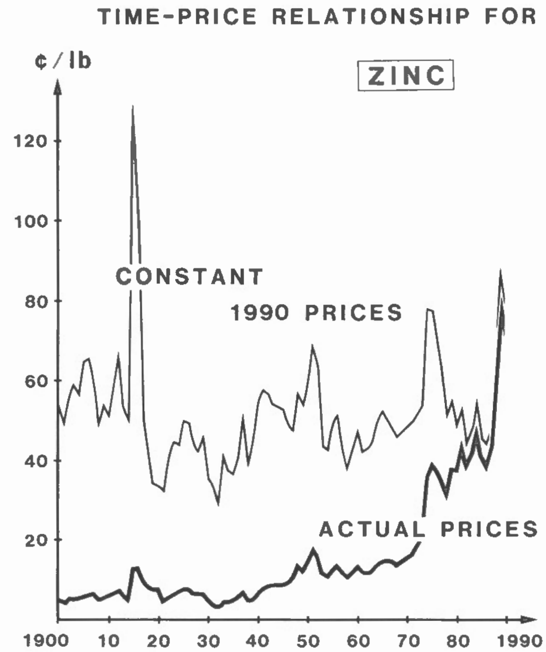


10 a

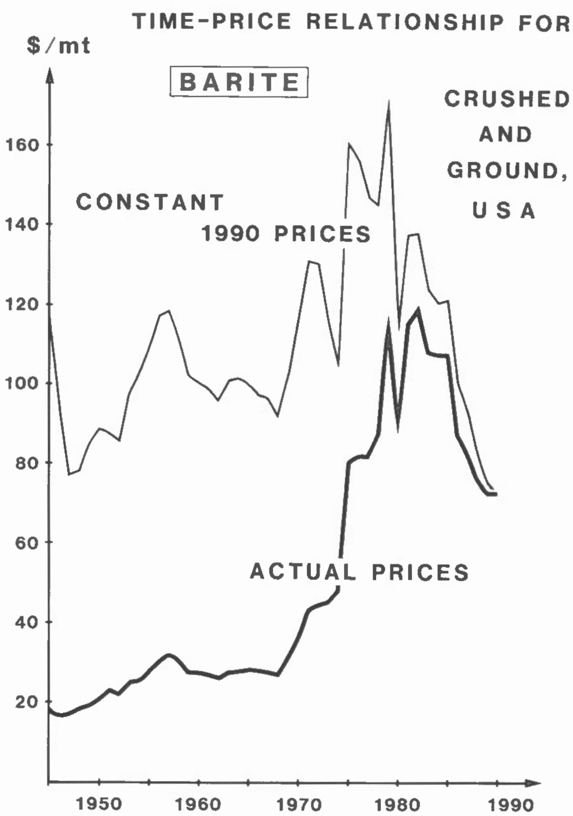


10b

Figure 11: Trend of zinc (a) and barite prices (b) in real (1990 US $) and nominal terms between 1900 and 1990 (inflation index: US producer price index)

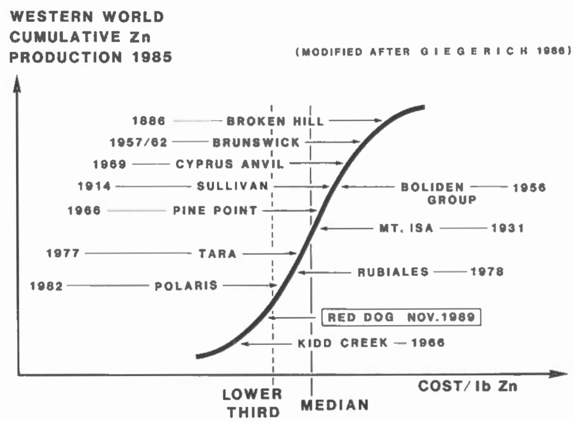


11a



11b

Figure 12: Cumulative frequency distribution of Zn production costs at major production centres in 1985 (western world). Dates refer to start of production at the various mining centres (modified after Giegerich, 1986)



Technological innovations

Two innovative processes will be mentioned that changed the supply situation for certain commodities:

- the development of the Imperial smelting (IS) furnace in the 1960's, which enabled mixed and fine grained lead/zinc concentrates to be smelted; this had the effect that very fine-grained Pb-Zn deposits, from which separated Pb and Zn concentrates could not be produced economically before, could now be exploited (CISSARZ *et al.* 1974).
- the argon-oxygen-decarburisation (AOD) and the vacuum-oxygen-decarburisation (VOD) processes which enabled chromite with lower Cr:Fe ratios to be used. (Harnisch *et al.* 1986)

Environmental Restrictions

As an example, Table 2 shows the much stricter emission standards recently introduced for German nonferrous metal plants in comparison to the standards of 1974.

Table 2: Emission Standards for the Nonferrous Metals Industry in Germany (from Liesegang, 1986)

Metal	Technical Regulation Air	
	1974 upper limit	1986 upper limit
Cadmium	20 mg/m^3	0.2 mg/m^3
Mercury	20	0.2
Thallium	20	0.2
Arsenic	20	1
Cobalt	50	1
Nickel	20	1
Selenium	20	1
Tellurium	20	1
Antimony	50	5
Lead	20	5
Chromium	20	5
Cyanide	-	5
Flouride	20	5
Copper	75	5
Manganese	-	5
Platinium	-	5
Palladium	-	5
Rhodium	-	5
Vanadium	20	5
Tin	-	5

Table 3: Grade of Accessory elements in Fe-ore for German blast furnace

	1976 %	1986 %
Al_2O_3	2,0	1,4-1,6
Mn	0,6-1,0	0,1-0,3
P	0,08-1,0	<0,04
K_2O + na_2O	<0,15	0,05-0,08

(source: Kegler & Wens , 1987)

Table 4: Changing quality requirements in basemetal concentrates

Concentrate	impurity	1970s	1990s
mixed Pb-Zn concentrates	Hg	70-80 g/t	<30 g/t
Zn concentrate	Cd	not relevant	<0,2 %
	elementary S	2-3 % accepted	<0,5 %
	Th	not relevant	sensible
	Se	not relevant	sensible

(source: priv. com. various industry sources)

THE GLOBALIZATION OF THE MINERAL MARKET

One of the consequences of these tougher restrictions and the pressure of costs is a tendency to use cleaner and cleaner raw materials in our smelters and factories. This is illustrated with four examples in Tables 3 and 4:

- Iron-ore for German blast furnaces;
- Barite and celestite concentrates for the barite chemical industry;
- Fluorite concentrates.

Although these differences (shown in the tables) in quality requirements seem small at first glance, they have in fact meant the end of production for certain mines and even mining districts.

Cost pressure combined with prices not increasing in real terms in the long run, as well as higher quality requirements, are forcing the production centres into a new wave of concentration. Figure 13 shows the share accounted for by the first three largest producer countries of iron-ore, bauxite and copper.

Figure 13: Share of global bauxite production accounted for by the three largest bauxite producer countries (%). The same for iron ore and copper (sources: KUCK& CVETIC, 1991, Metallgesellschaft AG, BGR databank)

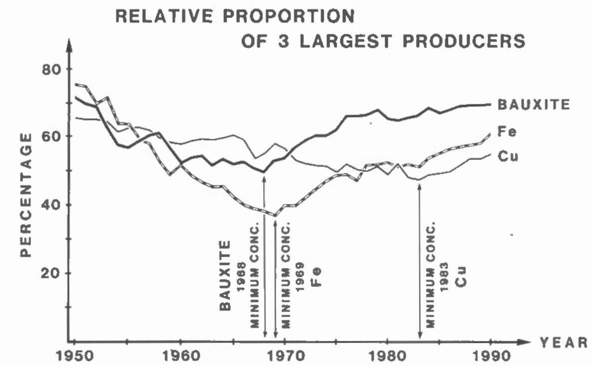
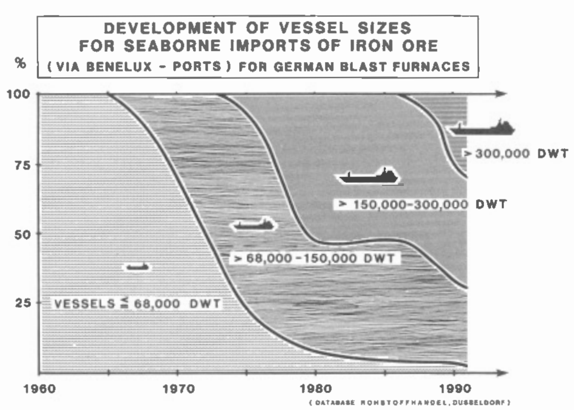


Figure 14: Rotterdam (source: priv. comm. Rohstoffhandel, Dusseldorf)



A further consequence is that, helped by a revolution in shipping, raw material markets have become far more global, meaning that individual producer nations face stiffer competition. Consumers will buy anywhere in the world where they find a suitable clean product at the right price. The days when low grade iron ore mines in Germany had a chance because they were located close to a blast furnace are long gone. Not only the better quality of foreign iron ores, but of course the revolution in bulk transport too, have forced mines to close down, as shown in Figure 14.

Today it is as expensive to transport iron ore from Brazil to Rotterdam as it is to transport it with barges on the River Rhine to blast furnaces in the Ruhr district in Germany, not to speak of rail freight to other landlocked industrial centres, which is much more costly.

THE TASK OF GEOLOGICAL SURVEYS OF PRODUCER NATIONS

After having looked at various aspects of the resource/reserve base, we should return to discuss the task of geological surveys of producing nations. For geological surveys of producing nations it is important to lay a sound foundation of data and expertise so that deposits can be discovered which can compete costwise and qualitywise on the world commodity markets, meaning that these deposits should clearly lie in the centre of the resource/reserve base discussed previously.

And last, but certainly not least, these deposits should be large deposits so that they can have an impact on the national economy and can support mining centres like Kalgoorlie, Broken Hill, Mount Isa in Australia or Timmins, Elliot Lake, Mattagmi, Chibougamau in Canada. One avenue of research might be, therefore, to characterize the geological environment of giant deposits, such as the Kidd Creek deposit. The GSC has started a programme to investigate the geological environments of significant base-metal camps.

One can conclude, therefore, that the work of the geological survey of a producer nation is basically value-oriented and will be value-oriented in the future, because mineral deposits will become depleted and will have to be replaced. As has been outlined, despite more efficient use of raw materials the economies of the world still require primary resources.

THE TASK OF GEOLOGICAL SURVEYS OF CONSUMER NATIONS

However, the more a country becomes solely a consumer nation and loses its position as a mining country, the more the tasks of geological surveys become volume-oriented. What is the reason? I want to illustrate this volume-orientation with the following examples: construction raw materials, ground water and waste disposal.

a) Construction raw materials
The transition from a mining country to a purely consuming country can be documented by the increasing ratio of industrial minerals and construction materials production to total metal production (Table 5). After the metal mines have been closed down, as is the case in Germany now, what is left are the industrial minerals and the quarrying industry which mainly supplies construction materials to local markets. Most construction raw materials are measured in m^3. If we look at the task of the geological surveys in Germany, they have to ensure that in land-use planning those areas underlain by near-surface mineral resources are not sterilized by other forms of development or even by legislation; for these are the areas where our future supply of construction material will be obtained. If one combines quarry depth with the area concerned, the result is a volume issue.

Table 5: Mining production (non-energetic) Industry minerals + construction material

Country	Value-Ratio Metal ore
European[1] Community	9,8
USA[2]	1,7
Canada[3]	0,42
Australia[4]	0,21
Republic of South Africa[5]	0,13

Sources:

[1] BGR databank, 1992

[2] USBM, Mineral Commodity Summaries 1992

[3] EMR, Canadian Mineral Industry, Jan. 1991

[4] BMR, Australian Mineral Industry, Annual Review 1987

[5] MB, South Africa's Mineral Industry 1991

b) Groundwater
Water, being a fluid, is measured by volume. One of the major tasks of geological surveys in this field is to identify and help protect those areas from which the groundwater can be pumped to supply the major population centres. Here again, area translates into volume.

c) Waste Disposal
i) A major problem today in our densely populated country is to find the necessary sites for waste disposal. The latest statistics are from 1987 and show that during the eighties about 230 million t per annum of waste, equivalent to 230 million m^3/a had to be dealt with (BMU 1990, BMT 1990)

ii) The Federal Institute for Geosciences and Natural Resources (BGR) has a direct responsibility for nuclear waste disposal, because according to our constitution nuclear matters are a federal responsibility. The uranium used in the fabrication of a fuel rod has, for those coming from a producer country, a value aspect. When the fuel rod is burnt up, it poses a volume problem. Germany must find the necessary space to safely dispose of nuclear waste for many centuries. Up to the year 2000, the waste will amount to about 3400 m^3 of highly radioactive, meaning heat-generating, waste and about 175,000 m^3 of low radioactive material, meaning that it generates negligible heat (BfS, 1991). The current plan is to use an old iron mine for the latter and a salt dome, which we are now investigating, for the former.

d) The last iron ore mine in Germany
As an example, the last producing iron ore mine in Germany (Wohlverwahrt-Nammen) is actually still in operation, not because it produces value, namely iron ore, but mainly because it produces volume, i.e. space underground in which fly ash from power plants can be stored as backfill - of course for a good fee.

I started by referring to the tonnage and value pyramids. I now want to introduce (Fig. 15) the volume pyramid, to which are added those commodities based on engineering technology that present big disposal problems; i.e. cement (concrete as demolition waste) and plastics. Everything that cannot be recycled or burned will be a volume problem for disposal.

Increasing recycling efficiency, whether prompted by public awareness, political pressure or cost pressure, can of course have significant impact on the primary material we use. Figure 16 shows the amount of glass recycled in Germany and the amount of primary raw material saved by recycling this glass.

A further step has to be taken. Today, geoscientists should have a wide-ranging view and follow the life cycle of materials from source to sink. In order to minimize material losses and environmental impact, they should consider bulk flow systems including wastes from exploitation and processing. In Germany the cost of finding sites for waste disposal and the planned waste tax are encouraging smelters and power plants in particular and all factories in general to operate as far as possible on a residue-free basis. In this context, the residues such as

Figure 15: Materials pyramid based on volume, reference year 1987 (sources see Figs. 1a and b)

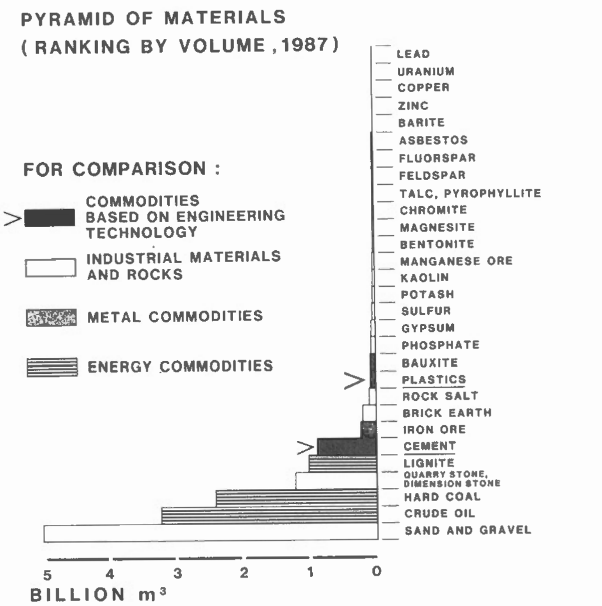


Figure 16: Amount of recycled glass in the Federal Republic of Germany, theoretical consumption of glass sand if no glass is recycled and glass sand consumed in reality with glass recycling (sources: priv. comm. German Assoc. of Glass Manufacturers)

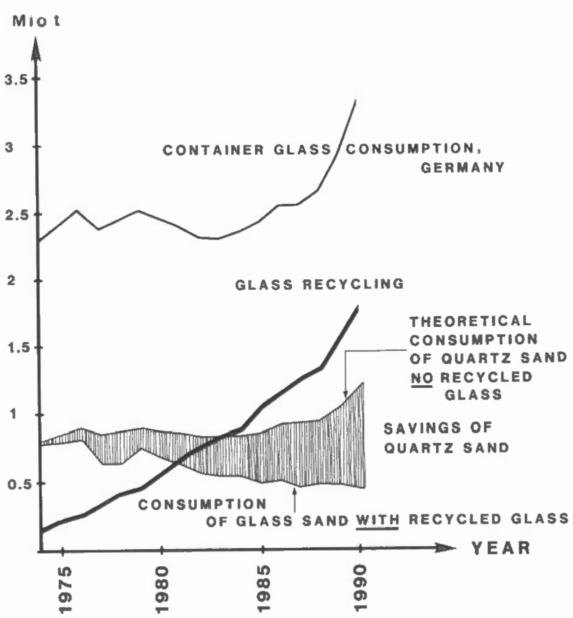


Figure 17: Schematic product and material flow of a power plant

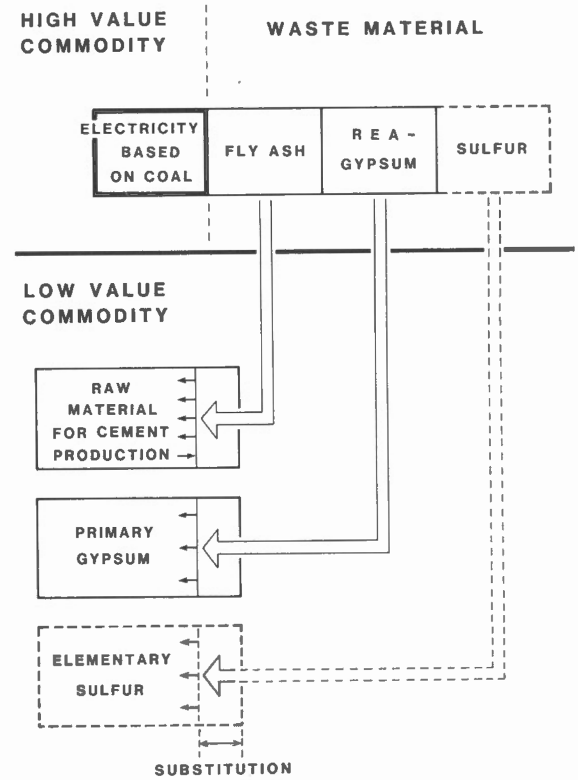
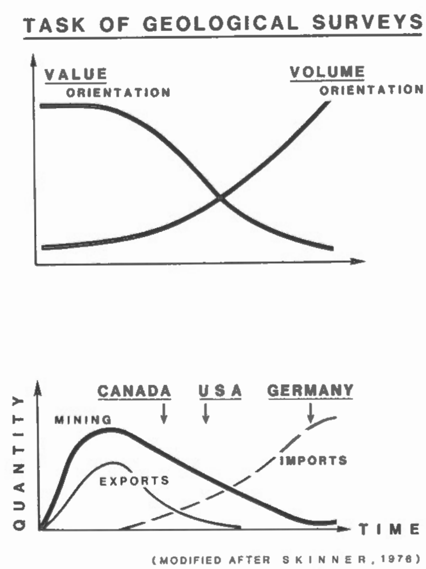


Figure 18: Changing nature of tasks of Geological surveys (Fig. 18 bottom modified after Skinner, 1976 and Hewett, 1929)



gypsum and elementary sulphur from power plants, or fly ash, which goes into cement manufacture, are actually substituting other lower-value primary raw materials (Figure 17). Thus, the volume aspect has a certain value aspect as a spin-off.

CONCLUSIONS

I started my presentation with the diagram in Figure 2 showing the transition of a country from a mining country to a consuming country. I want to finish my presentation using this graph again and adding the changing nature of the Geological Surveys' task. (Figure 18)

In summary, I do not foresee much change in the tasks of a geological survey of a mineral producing country; however, I expect to see significant changes stemming from the increasing importance of aspects typical of a consuming country. The transition of a country from a mineral producer to a mineral consumer is reflected in the volume aspect of mineral resources taking precedence over the value aspect. Empty space for depositories and storage becomes more and more important and this too means volume.

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Advanced Materials: Status and Development Trends

H. Czichos[1]

Czichos, H., Advanced Materials: Status and Development Trends; in National Geological Surveys in the 21st Century, Bouchard, D.S. et al. (compilers), Geological Survey of Canada, Bulletin 446, p. 89-100, 1993

Abstract

The great importance of materials science and engineering for future techno-economic developments has now been recognized in all industrialized and industrializing countries. For a strategy to increase the value of products and engineering structures, R&D should result in materials and products of high consistency, quality and reliability, and with improved processability, performance and durability; besides that, environmental requirements must be met in the development and application of advanced materials and products. This paper gives an overview on status and development trends of advanced materials based on a recent study for the European Communities.

Résumé

Tous les pays industrialisés et en voie d'industrialisation ont maintenant pris conscience de la grande importance que revêtent la science et le génie des matériaux pour les progrès technologiques et économiques. Pour augmenter la valeur des produits et des ouvrages de génie, il faut que la R-D mène à des matériaux et produits d'une précision, d'une qualité et d'une fiabilité élevées, offrant une transformabilité, des performances et une durabilité améliorées. Par ailleurs, la mise au point et l'utilisation des matériaux et produits de pointe doivent satisfaire à des exigences environnementales. La communication présente un aperçu de la situation actuelle et des tendances dans le domaine des matériaux de pointe, aperçu basé sur une récente étude réalisée pour la Communauté européenne.

First of all, from our institute, the Federal Institute for Materials Research and Testing in Germany in Berlin, I'd like to congratulate the Geological Survey on this very important anniversary.

INTRODUCTION: SCOPE OF ADVANCED MATERIALS

Materials constitute the physical matter of all things produced by humans; they are thus a key factor in all technologies. The driving forces behind the development of "advanced materials" are various technological, social and environmental requirements; for example: improved performance, integrity and reliability of engineering components and systems; higher durability of products; higher-efficiency, lower-energy consuming engines; light-weight, high-strength structures; high-speed information technologies; increased productivity.

Although the term "advanced materials" cannot be defined precisely, in a broad interpretation the following substances may belong to this category.

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(a) Materials with a new composition or microstructure:
- inhomogeneous
- amorphous
- nanocrystalline

(b) Materials providing novel applications through improved development and processing:
- synthesis
- design
- production (incl. assembly and joining)

(c) Materials with improved properties:
- structural properties
  mechanical
  thermal
- functional properties
  electrical
  magnetic
  optical
  biological
- performance properties
  complex behaviour (incl. corrosion, tribology)
  environment compatibility (incl. recycling, deposition)
  quality, safety, reliability

This paper analyses the underpinning and enabling role of advanced materials for contemporary engineering and future technologies.

IMPACT OF MATERIALS FOR CONTEMPORARY TECHNOLOGIES

It is generally recognized that industrial and materials technologies play a key role in the economies of all industrialized countries. The manufacturing industries provide in the main trading blocks, namely the United States of America, Japan and the European Communities (EC) around 28%, 41% and 28%, respectively, of the Gross National Product (1988). For the EC, an overview on main industrial sectors by output and employment is given in Table 1.

Table 1: Overview on industrial sectors in the European Communities (EC) by output and employment (1988)

Industrial sector	Output (billion ECU)	Employment (1000)
Building and civil engineering	412.6	8447
Chemicals	263.9	1678
Motor vehicles, parts and acessories	206.7	1815
Mechanical engineering	190.9	2344
Electrical engineering	187.8	2391
Manufacture of metal articles	145.5	2123
Production of metals	125.8	920
Textile industry	84.3	1548
Processing of rubber and plastics	80.7	981
Manufacture of mineral products	80.1	977
Computer and office equipment	39.9	239
Air transport	24.7	259
Instrument engineering	20.3	309

As indicators for the importance of the various sectors the following aspects may be considered:

- EC export rates to the world
- Product share of EC exports to the world.

In Figure 1 these indicators are shown for basic industrial sectors.

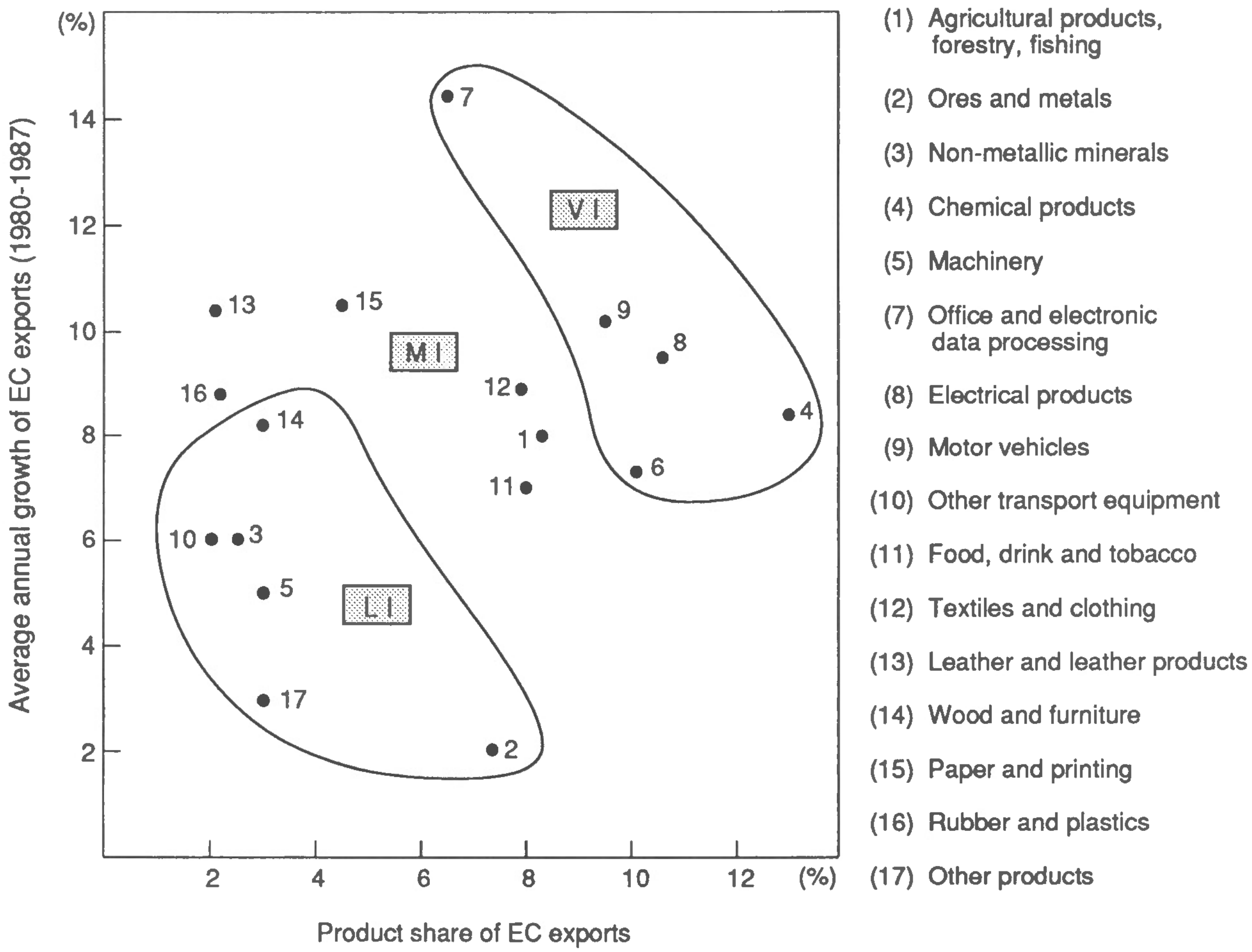
The industrial sectors as characterized by their importance to EC trade can be allocated among three levels which may be called "very important" (VI), "moderately important" (MI), and "less important" (LI). The sectors which are currently of dominating importance in the EC are:

- Chemical products
- Office and electronic data processing
- Electrical products
- Motor vehicles
- Machinery

Because of the impact of the various products and technologies there is great concern in all industrialized countries to maintain or to increase the competitiveness in industrial sectors through technological improvements and innovations. According to a study of the organization for Economic Co-operation and Development (OECD) on "New Technologies in the 1990s" (1988) for a technology to have pervasive economic effects and employment implications it must:

(i) Generate a wide range of new products and/or services,
(ii) Have applications in many sectors of the economy,
(iii) Reduce the costs and improve the performance of existing processes, products and systems,
(iv) Gain widespread social acceptance with minimal opposition, leading to a favourable regulatory framework,
(v) Generate strong industrial interest based on perceived profitability and competition advantage.

Figure 1: Relative importance of product sectors for EC exports to the world



In this context, materials technologies play a crucial enabling role (OECD, 1990) for industrial components and products, and their design and processing in the following main aspects:

(a) Structural components and products:
Structural components are the elements of any technical product or engineering system subject to mechanical or mechanical/thermal loads and stresses. There is a continuous need to improve and to develop new structural materials, especially in the following sectors:

- In the engineering industry and robotics through new equipment and processing technologies, e.g. welding, assembly, bonding, use of laser
- In the car industry by means of steel improvement, the substitution of metals by plastics and attempts to lighten vehicles
- In the aerospace industry where composites are making progress and where the outlook for certain alloys, for example aluminium/lithium, seems promising
- In housing, because of beneficial properties of advanced materials with respect to heat insulation, anti-vibration or mechanical stability
- In the health sector where biomaterials such as implants or prostheses are increasingly important
- In the sport and leisure industry

(b) Functional components and products:
Materials play in advanced industrial sectors an enabling functional role when their performance standards are very high in a certain area or when they provide a range of useful properties, especially of an electrical, magnetic or optical nature. They are then often the key to new technical systems such as silicon semiconductors in the electronic field, glass fibres for cable telecommunications, rare earths for magnets or optical applications and ceramics for combustion engines and sensors.

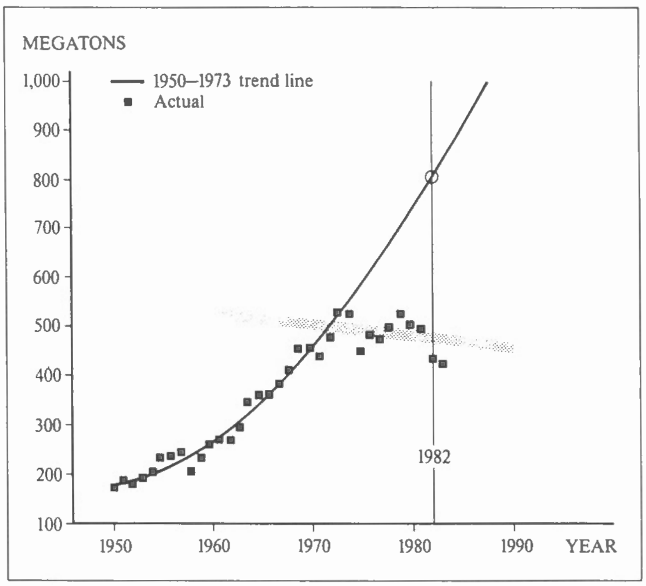
(c) Design:
Progress in materials developments enlarge the portfolio of available choice to the industrial designers and enable the most desirable qualities and attributes to be chosen at an early stage. This "customising" of materials is closely associated with the introduction of computer-aided design (CAD) and other information technologies.

(d) Processing:
The large number of contemporary methods of treating and processing advanced materials - for example, reactive or injection moulding, extruding, stamping, superplastic forming, ultra-rapid solidification, powder metallurgy, sol-gel methods, vapour deposition, epitaxy - affects the market for equipment needed to produce the corresponding parts. The possibilities of robotizing and computerizing their production adds further to the range of possible applications.

With respect to possible materials-related trends in industrial technologies there are two general dimensions to be considered (Czichos et al., 1988):

(i) Increased efficiency of material use and substitution by new materials can cut heavily into the demand for conventional minerals and metals. Consider, for example, the western world steel consumption over the last three decades, which was only 50 percent in the 80's as compared with the expectations based on an extrapolation of the actual consumption in the years 1950 to 1973 (Figure 2) (Murthy and Taylor, 1988). The pessimistic predictions made by the Club of Rome in 1972 in its study "The Limits of Growth", namely that existing deposits of industrially important metals for example lead and zinc would be exhausted by the year 2000 turned out to be false. Today, almost 20 years later, no shortage of any mineral resource can be foreseen for several decades to come (Kürsten et al., 1988).

Figure 2: Steel consumption in the western world



(ii) The second dimension of new materials technologies relates to the opportunities being created for new products and substitutes. Advanced materials form the basis for almost all new industrial products - from optoelectronic equipment and sophisticated sensors to high-density data storage and advanced semiconductor devices. Projected sales figures of some "high-tech areas" for the year 2000 in the USA are shown in Figure 3.

The introduction of new materials and the further development of conventional materials lead to changes in most industrial sectors. The changes taking place in the automobile and aircraft industries are perhaps the most noteworthy because of the future implications.

The changes in materials use in US passenger cars in a period of 10 years is given in Table 2 (Murthy and Taylor, 1988). It is readily seen that, generally speaking, iron and steel are being increasingly replaced by plastics, composites and aluminium. In this connection it should be noted, however, that although the proportion of iron and steel is decreasing in total, the percentage of the share of high-strength low-alloy (HSLA) steels is increasing.

Figure 3: Projected US sales figures in high-tech sectors for the year 2000 (Source: US Department of Commerce)

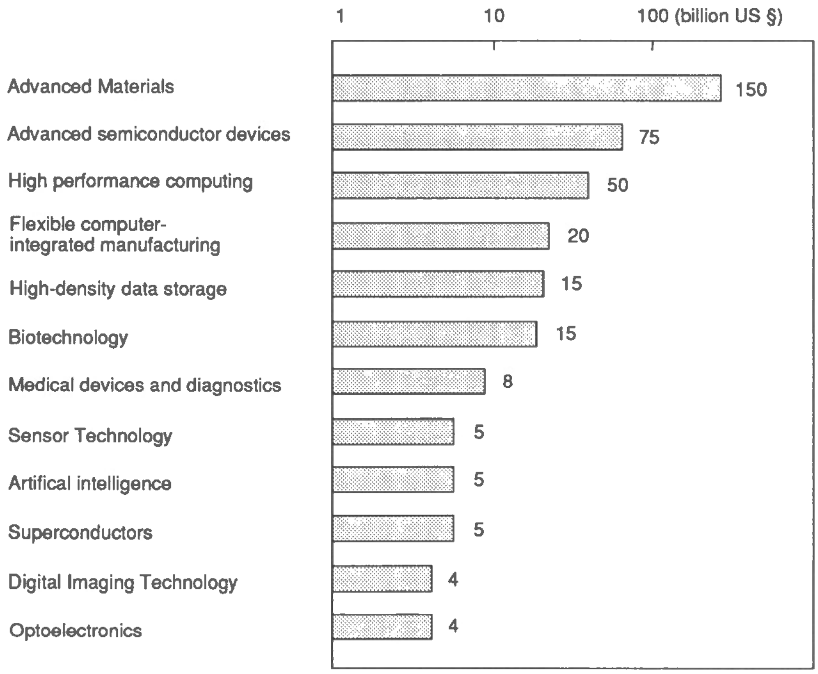


Table 2: Changes in materials usage in US passenger cars in a period of 10 years

Material	1976	Kg per car 1986	Growth rate (% / year)
Iron and steel	1278	1010	- 2.4
Plastics/composites	73	97	+2.9
Aluminium	38	63	+5.0
Glass	39	38	0
Others	262	217	- 1.9
Total	1692	1426	- 1.7

Trends in materials applications for commercial aircraft structures are shown in Figure 4 (Murthy and Taylor, 1988). It is anticipated that by the year 2000, fibre-reinforced composites or possibly aluminium-lithium alloys will have replaced most of the today's conventional alloys in aircraft structures.

A global world market outlook for new materials by product categories and industrial sectors has been attempted in a recent French study (Ullmann, 1989). According to Table 3, new or improved steel products account for half of all new materials with expected average annual growth rates of about 2 percent. Ceramics, which account for only one tenth of the total sales have an expected growth rate which is about four to five times higher than that of steel products.

The different sector's relative positions change if we examine growth rates of new materials use (Figure 5). Packaging, aerospace engineering, automobiles, and sports

Figure 4: Trends in materials use for commercial aircraft

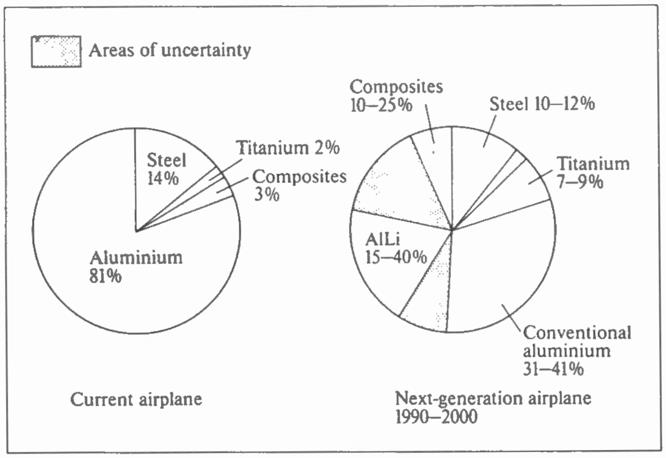
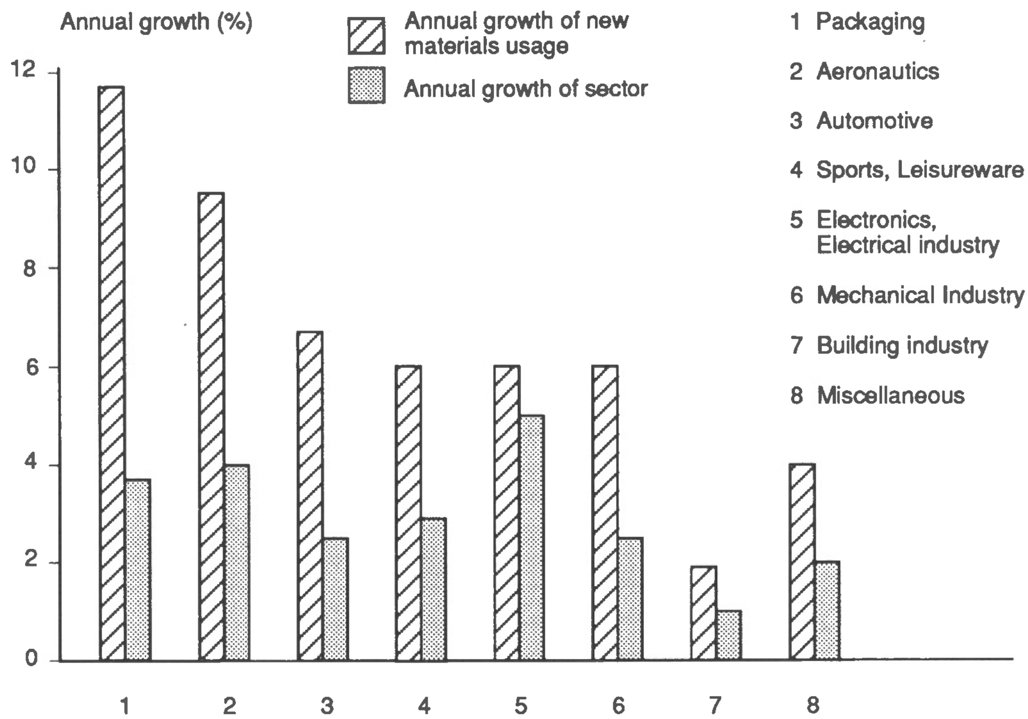


Table 3: New materials market breakdown by material type (1988)

New materials	Market (GF)	Annual growth 1988-1995 (%)
New steel	365	+ 2.8
Technical thermosets	123	+ 4.9
Materials for electronics	119	+ 12.0
Non ferrous metals	107	+ 2.8
Composites	99	+ 8.9
Technical thermoplastics	90	+ 8.7
Ceramics	60	+ 11.9
New glass materials	39	+ 9.6
Total	1002	+ 6.5

Figure 5: New Materials usage forecast by end user sector in Europe (1988)



and leisure have the highest consumption growth rates, and packaging has the very highest. The high expected growth rate for new materials use in this sector is due, not to an increase in production, but to an expected rapid change in the materials used by this sector. Construction, on the other hand, has until now been slow to adopt new materials.

RESEARCH AND DEVELOPMENT TRENDS IN INDUSTRIAL AND MATERIALS TECHNOLOGIES

In order to determine on a broad basis R&D needs in industrial and materials technologies in Europe, a study was made on behalf of the Commission of the European Communities (Czichos, Helms and Lexow, 1991). A questionnaire was developed and sent to about 700 institutions in all countries of the European Communities consisting of industries, universities and research organizations. In addition interviews were held with partners from the following sectors: aircraft and aerospace, automobile, building and civil engineering, ceramics, chemical engineering, electrical engineering, electronics, instrument engineering, iron and steel, machinery, mechanical engineering, powerplants. A response of 140 filled-in questionnaires reflecting the main industrial, technological and scientific sectors was received with the following distribution: (i) industry: 70%, (ii) universities: 24%, (iii) research organizations: 6%.

For the evaluation of the answered questionnaires a databank computer programme was applied. From the answers in the questionnaire a total of 3010 entries was fed into the computer and the distribution of answers with respect to basic materials-related aspects was determined.

Figure 6 indicates that a broad spectrum of industrial branches is interested in R&D in industrial and materials technologies, namely

- Chemical industries
- Electrical engineering
- Mechanical engineering
- Motor vehicles
- Aerospace
- Civil engineering

Other specific industries - which contribute to about 50 % of the response of the questionnaires were summarized under the general term "engineering industries".

The general tasks which have been named by the various industries as priority themes for research and development in industrial and materials technologies are summarized in Figure 7. Three quarters of all answers are related to the following topics of overall (medium-term) importance:

- Cost reduction
- Environment compatibility
- Energy and materials savings.

Figure 6: Industries interested in research and development (928 entries = 100%)

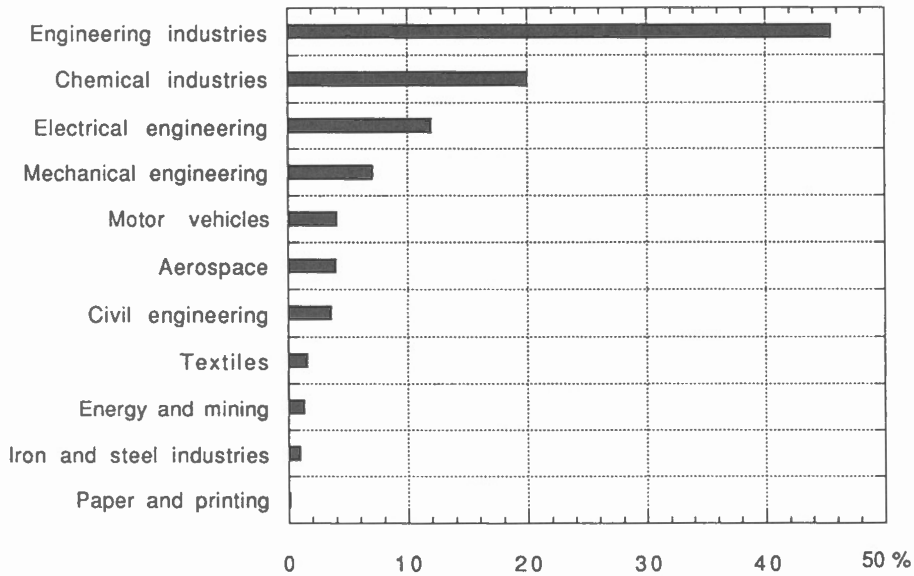
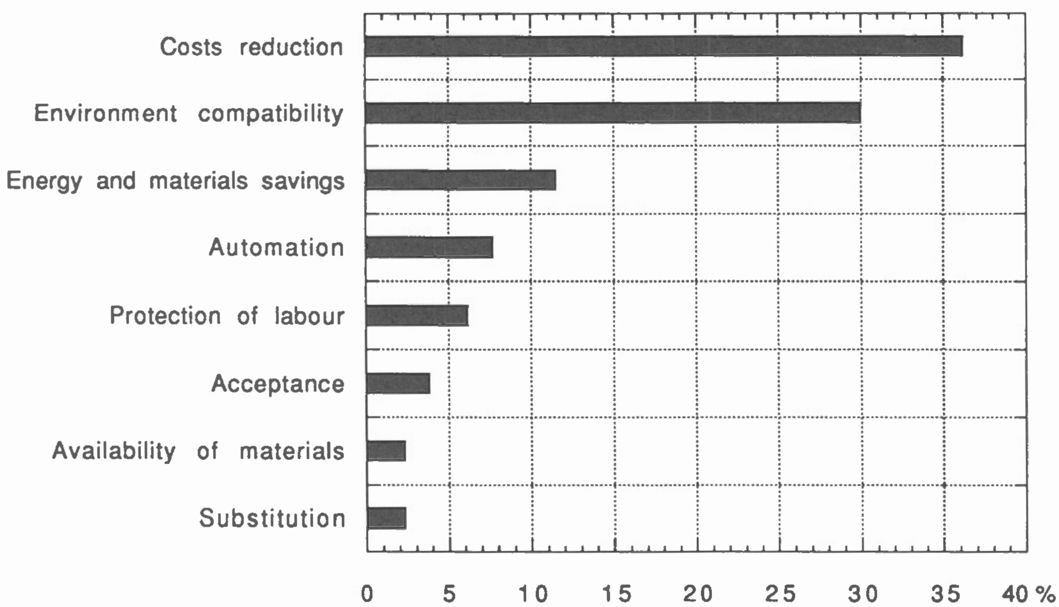


Figure 7: General tasks for R&D in industrial and materials technologies (130 entries = 100%)



For the industrial products which may result from intensified R&D, the following topics are of paramount importance (response of about 80 %) as can be seen from Figure 8:

- Recycling aspects
- Long-term performance
- Functional purpose

MATERIALS AND MATERIALS PROPERTIES SUGGESTED FOR R&D

In the field of materials, the highest interest is in composites (30%) followed by ceramic materials (20%), metals and alloys (19%) and polymers (17%), see Figure 9. The main materials properties suggested for R&D are compiled in Figure 10.

Figure 8: Products characteristics suggested for R&D (156 entries = 100%)

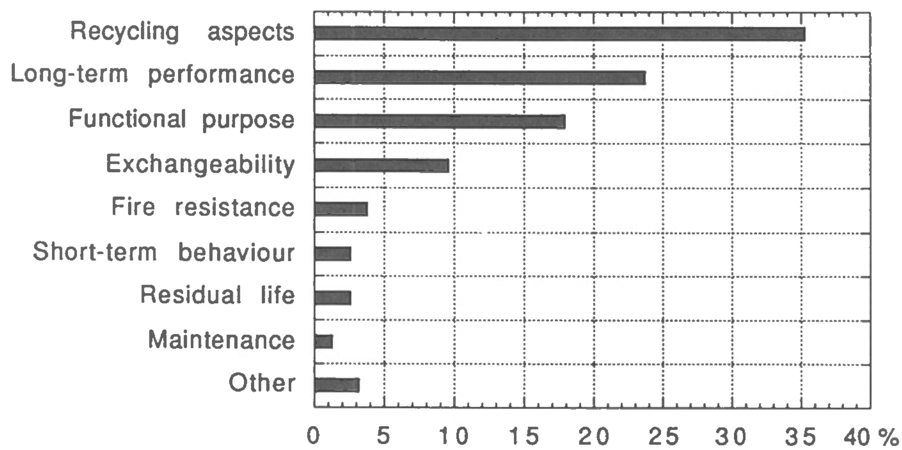


Figure 9: Types of materials suggested for R&D (596 entries = 100%)

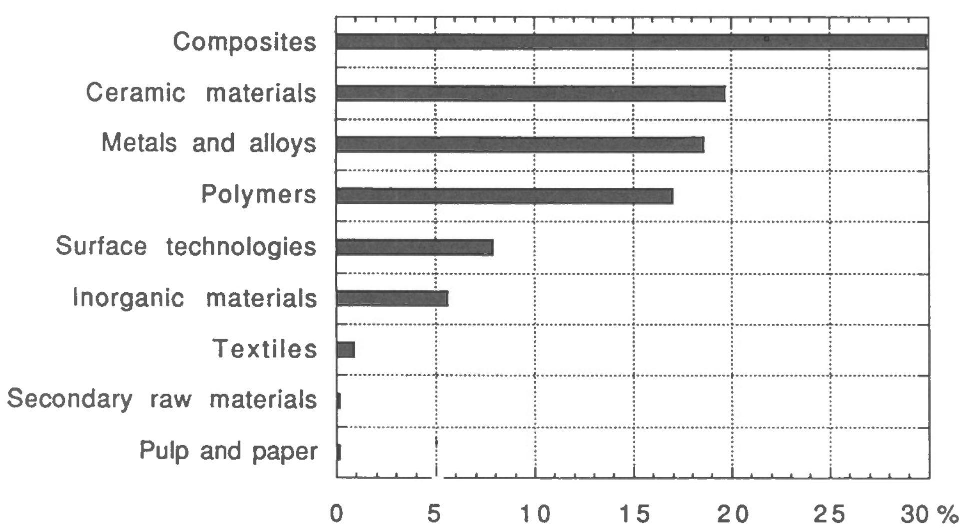
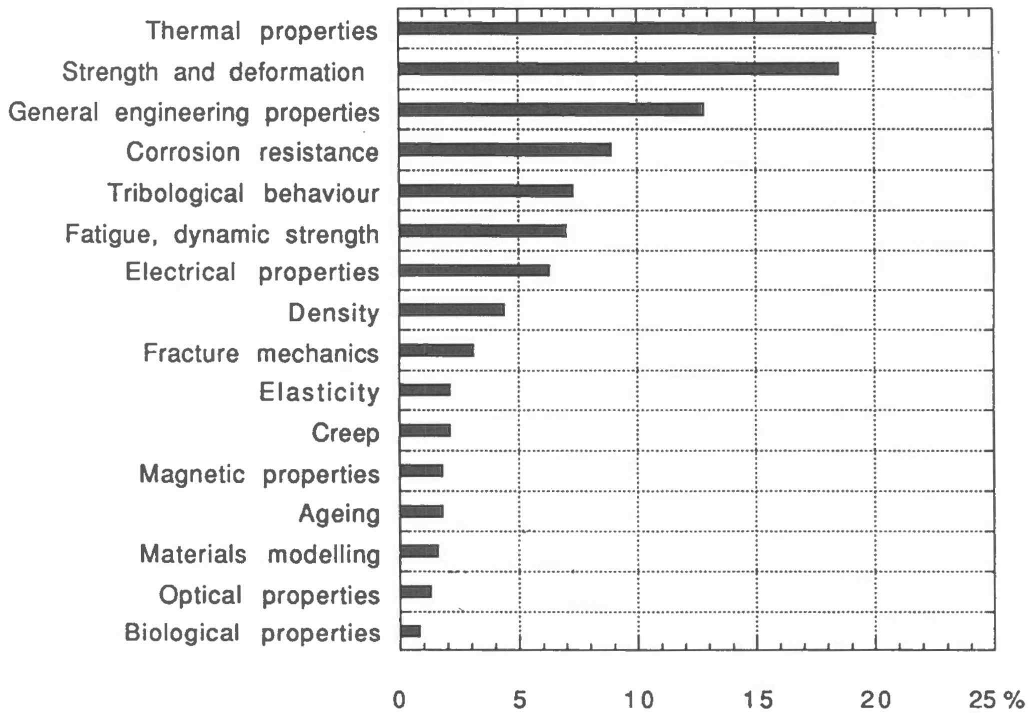


Figure 10: Materials properties suggested for R&D (383 entries = 100%)



With respect to materials and materials properties suggested for future R&D in Europe, a large variety of details was given in the questionnaires. For the main classes of materials mentioned above, the themes which correlated in substance are listed below in an approximate order of importance

Composites

For the present purpose, it is reasonable to subdivide the entries for the total class of composites (100%) into those for polymer matrix composites (47%), metal matrix composites (15%) and ceramic matrix composites (7%). The remaining percentage is attributed to concrete composites and other general entries which have not been specified. In detail, the following themes are of interest:

(a) Polymer matrix composites (PMC):
- High temperature performance
- Increased stiffness and low density
- High strength and fracture toughness, improved damage tolerance and compressive properties.
- Improved resistance against aggressive agents.

The following types of PMC have been mentioned for special interest:
- Thermoplastic matrix composites
- Composites with short fibre and sub-μm reinforcement as well as those in the molecular range.
- Composites with whisker reinforcement
- Composites for low temperature processing.

Additional indications with respect to an improvement of the mechanical properties are expected from investigations on:
- Effects of fibre alignment as well as on
- Fibre-matrix interface properties, e.g. the debonding effects.

(b) Metal matrix composites (MMC):
Prominent themes are:
- Al-matrix composites with ceramic fibres; upgrading of strength and stiffness;
- Compounds with a combination of high strength and good corrosion resistance;
- Compound materials and structures with special properties profiles.

Again, the effect of fibre alignment on the mechanical properties is of interest.

(c) Ceramic matrix composites (CMC):
Themes of special interest are:
- Resistance against high temperature and chemical attack; and
- Upgrading with respect to strength, fracture toughness and damage tolerance.

Of further interest are the reinforcement with whiskers and other short fibres as well as the effect of the fibre alignment and that of the interface properties on the debonding of the fibres.

Ceramic materials (monolithic engineering ceramics)

For the class of monolithic engineering ceramics, an upgrading with respect to the following aspects is of general interest:
- Strength in general
- High temperature properties with respect to strength, creep resistance and inhibition of grain growth
- Brittleness and fracture toughness
- Fatigue strength
- High temperature corrosion resistance
- Resistance against chemical attack
- Tribological behaviour (friction, wear)

Out of the variety of engineering ceramics, the class of non-oxide ceramics (SiC, Si_3N_4, B_4C, BN) seems to be of special interest, whereas the necessary improvement of the reliability of ceramic structures in general leads to further R&D activities in the fields of powders and agglomerates (< 1 μm) as a basic material for engineering ceramics. In this context, the surface chemistry of the powders and the manufacturing and application of "nanomaterials" is discussed.

Further ceramic materials of interest for R&D activities are:
- Functional ceramics with special electrical, magnetic and optical properties,
- Ceramic coatings,
- Glass and glass ceramics with respect to an upgrading of strength and toughness,
- Refractories for melting furnaces etc.
- CERMETS (ceramic/metal compounds).

As a general R&D theme, the development of proper constitutive models for the deterioration mechanisms of brittle materials was recognized.

Metals and alloys

Of special interest for R&D activities are those metallic materials which promise further upgrading of the high temperature behaviour (strength, creep resistance, high temperature corrosion resistance) for application in gas turbines, jet engines, chemical processing lines etc.:
- High temperature steels
- High temperature superalloys of the polycrystalline, directionally solidified and single crystal type
- Mechanically alloyed (MA) Ni-base alloys
- Intermetallics, e.g. of the Ni-Al-type for high temperature application
- Ti-alloys for the medium temperature range.

Further activities are desired with respect to an upgrading of low density metals such as:
- Mechanically alloyed Al- and Ti-alloys (strength at higher temperatures)
- Al-Li-alloys for the aircraft industry (density, stiffness)
- Li-alloys (extreme low density).

Nanocrystalline metals and amorphous alloys manufactured by rapid solidification techniques are, furthermore, prone to further research.

For a plurality of conventional materials, an improvement is requested especially with respect to economical effects and competitiveness:
- Micro-alloyed steels with respect to an enlargement of the field of application; acceptance in regulations
- Cast metallic materials by advanced processing routes; easy recycling
- Austempered nodular cast iron
- Duplex-structure stainless steels
- Materials and structures via powder metallurgy routes; higher relative density
- Metals with superplastic properties
- Magnetic alloys with minimized losses.

And, finally, further research on the correlation of microstructure and mechanical properties has been recognized as a general future task.

Polymers

For the class of polymers and polymer blends, one of the main themes of interest for R&D is focused to an upgrading of the properties at higher temperatures:
- Flow (creep) resistance at elevated temperature,
- Thermal resistance (e.g. at soldering temperatures)
- Hydrothermal stability
- Thermal conductivity
- Fire resistance without use of halogen elements.

Importance is also attributed to the electrical conductivity - especially reversible (switch on/off), as well as to low electrical charging. Strength and toughness are generally upgrading candidates for polymers. Other properties such as:
- Chemical endurance and resistance against aggressive agents
- Low coefficient of friction and high wear resistance
- Special optical properties

are of special interest, whilst good biological degradability and recycling properties are of vital importance for future application of this class of materials.

R&D activities are necessary also for polymer biomaterials (engineering inside the body). With respect to this application "tailor-made" materials with suitable mechanical properties, no degradation inside the body and no release of toxic monomers are required.

Quite different properties are important for polymer materials which are optimized with respect to an application in the textile and shoe industry. Low density, high damping capacity and wear resistance as well as special porosity are required here.

Other materials

In addition to the R&D topics with respect to the four main materials classes, suggestions for R&D concerning other types of materials have been made as outlined in the following:

- Materials for information technologies: Microelectronics, circuit boards; materials with integrated optics; high purity materials of special composition for the computer technology; substrates for thin coatings; semi-conductors with diamond structure

- Coating materials: Coatings made from hard materials (wear resistance); ion implantation, laser hardening; sputtered thin coatings for the computer technology, impact resistant coatings; functional coatings of high surface performance and corrosion resistance

- High temperature superconductivity materials Application for energy technology (coils, magnets etc.); high critical current density; compound systems of HTS ceramics on metallic substrates; processing of HTS powders to wires

- Materials for civil engineering application: Concrete with composite cements and polymer additives and fibre reinforced micro-concrete (glass and steel fibres)

- Carbon materials and carbon fibres for composite materials

- Polycrystalline diamond with increased electrical conductivity and improved thermal properties; application for coatings

- Materials for catalytic processes.

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Theme III Discussion

K.. Skinner: Asbestos, a material which was being ripped out of every building, is made of fibres which is what composites are. In view of the last presentation, could I have some indication of where we are going in the composite field?

H. Czichos: Asbestos from a purely technical point of view is a marvellous material. However, we have to recognize that this type of material may do harm, and substitute for it. In our country, about 8-10 years ago, we brought together the people who make asbestos and the people who use and apply it. In a concerted action, there is a program to develop substitutes. We have made some progress and we can substitute in certain areas for this type of material.

Regarding composites in general, composites have some very good properties. For example, in certain areas of mechanical engineering you can make elastic strings for automotive applications. In the next generation of aeroplanes there will be materials made up of carbon fibre composites. So you have to consider first the function requirements and properties you need, and then add the other aspects, such as the recycling and social aspects. Nowadays we have to consider a systems approach to combine those aspects. In the past engineers were mainly interested in the function. In summary, in certain sectors of composite materials there is a lot of application-oriented research going.

C. Staudt: Professor Kursten, your picture with the volume site looked very reassuring. However, the consequence could be that if a country goes out of the producing phase, the tasks of the survey are greatly reduced and just the volume site remains. Does your picture ignore the possible consequences?

M. Kursten: I said that the volume aspect more and more takes precedence over production. Of course it is incorporated from the start. It's a change in relationship.

Z. Johan: Several weeks ago we had a big meeting in Paris about waste disposal and generation of waste. It was a big discussion between scientists and industrialists. The result was an equation which means: you are polluting more; you are depolluting more; you make much more money. We are trying to do something for the environment. Do you think we have to look at a new equilibrium between a new structure of industry and society?

M. Kursten: Certainly we need an equilibrium, but what is necessary now is to look at the whole system. We have to start from the raw material and at the same time we have to think of the end product, of the waste. We have to think about all our industrial products from source to sink. This could be one of the answers to Mr. Kesse, who asked, "Are you giving us your waste, and we have to supply you with our precious raw materials?" We have to insist on overriding systems which comprise the whole cycle.

THEME IV: NEW CONCEPTS AND NEW TECHNOLOGIES IN THE EARTH SCIENCES

New frontiers and technologies

N. Williams

Geological hazards in Japan, an industrialized country

K. Ogawa

Discussion

New Frontiers and Technologies

N. Williams[1]

Williams, N., New Frontiers and Technologies; in National Geological Surveys in the 21st Century, Bouchard, D.S. et al. (compilers), Geological Survey of Canada, Bulletin 446 p.105-111, 1993

Abstract

Geological surveys face many new frontiers, the most important of which arises from the growing challenge of sustainable development. In addition to the traditional role of undertaking work to ensure the availability of resources of minerals, fossil fuels, and water, a new and important emerging role is in environmental geoscience to ensure sound land management, land-use decisions, and resource management.

To fulfil these roles geological surveys must strive for new insights into both the geology of the earth's crust and its endowment of resources, and the regolith (weathered, in-situ and transported material which covers the bedrock) and its interaction with the biosphere, hydrosphere, and atmosphere. Technologies to meet the challenges of sustainable development are evolving rapidly and are aimed mostly at new approaches to data acquisition and interpretation. Most advances have been made possible by spectacular improvements over the last twenty-five years in the performance of computers.

New insights into the geology of the earth's crust are being gained in several ways that combine the power of modern computers with well-proven geological and geophysical survey methods. In Australia the National Geoscience Mapping Accord between the Bureau of Mineral Resources, Geology and Geophysics, and the state and territory geological surveys is producing a second generation of regional-scale geoscience maps and databases to:

- optimise the environment for mineral and fuel exploration;
- provide a reliable information base for the assessment of potential mineral and fuel resources; and
- strengthen the geoscientific information base required for sound environmental management and land use decision making.

Whereas the first generation of regional scale geological maps in Australia was underpinned by aerial photography, the second generation mapping is founded upon high-quality systematic airborne magnetic and radiometric surveys. By manipulating the data from these surveys using image processing techniques, geoscientists can map not only bedrock but also the regolith and the bedrock it conceals in a rapid and cost effective fashion that was impossible only a short time ago. The approach allows quick identification of errors in the first generation maps, but more importantly, it is routinely revealing features of importance that were either previously unsuspected or unimagined. As geophysical modelling and inversion procedures evolve, it is anticipated that these same data sets will become increasingly important in the generation of robust three dimensional geological models of the crust, especially when they are jointly inverted with other geophysical data such as those from gravity such as those from gravity and seismic surveys. Knowledge of the regolith is advancing rapidly as

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traditional field studies are being complemented by the results of airborne radiometric surveys, and surveys involving both aircraft and satellite mounted multispectral scanners.

Another important frontier is the incorporation of the time dimension to create four-dimensional models. Improvements in geochronology will benefit many aspects of geoscience such as sequence stratigraphy, where there is a need for greater precision in dating; metallogeny, where there is a need for better dating of mineralizing events; and environmental geoscience, where there is a need to measure rates of natural change as a framework for understanding anthropogenic change. One noteworthy technological advance in geochronology has been the development of ion-microprobes like SHRIMP as effective dating tools which are just beginning to have major impact on both sequence stratigraphy and metallogenic studies.

The effectiveness of these new approaches is unlikely to be limited by technology. Rather, there is evidence that conceptual geological thinking will limit progress because geoscientists are becoming more reliant on the power of computers to produce spectacular geoscientific images and geological models, and are paying less attention to field geology and the importance of scientific intuition in the development of new geoscientific concepts. Geographical information systems offer a means of meeting the challenge but care must be taken to ensure that those using these tools have a geoscientific background that is sufficiently strong to take full advantage of the technology.

In terms of sustainable development, probably the greatest challenge facing geoscientists, particularly those working in geological surveys, is how to present their data interpretations and concepts in ways that can be quickly and accurately appreciated by decision makers, and those who will be affected by their decisions. Unless outputs are user friendly there is a great danger that the value of geoscientific input to land use planning and resource management will be overlooked.

Résumé

De nouveaux horizons s'ouvrent aux commissions géologiques, dont l'un des plus importants est celui qui découle du défi de plus en plus grand que présente le développement durable. Au rôle traditionnel des commissions géologiques, qui consiste à entreprendre les travaux qui permettront de garantir la disponibilité des ressources minérales, des combustibles fossiles et de l'eau, vient s'ajouter une nouvelle fonction importante dans le domaine de la géoscience environnementale : veiller à ce que la gestion des terres, les décisions d'occupation des sols et la gestion des ressources soient compatibles avec la protection de l'environnement.

Pour remplir ces rôles, les commissions géologiques doivent chercher à mieux comprendre la géologie de l'écorce terrestre et ses richesses, ainsi que le régolite (couche de roches altérées autochtones et allochtones recouvrant la roche consolidée) et son interaction avec la biosphère, l'hydrosphère et l'atmosphère. Les technologies qui permettront de relever le défi du développement durable évoluent rapidement et sont surtout orientées vers de nouvelles méthodes d'acquisition et d'interprétation des données. La plupart des progrès ont été rendus possibles par le bond spectaculaire de l'informatique au cours des vingt-cinq dernières années.

La compréhension de la géologie de l'écorce terrestre est améliorée par plusieurs méthodes qui allient la puissance des ordinateurs modernes à des méthodes éprouvées de prospection géologique et géophysique. En Australie, l'accord national de cartographie géoscientifique que le Bureau des ressources minérales, de la géologie et de la géophysique a conclu avec les commissions d'état et territoriales mène à la production d'une deuxième génération de cartes et fichiers géoscientifiques à l'échelle régionale. Les buts visés sont les suivants :

- optimiser les conditions de prospection des minéraux et des combustibles;

- constituer une base fiable d'information pour l'évaluation des ressources potentielles de minéraux et de combustibles;

- renforcer la base d'information géoscientifique qu'exigent une gestion judicieuse de l'environnement et de bonnes décisions d'aménagement du territoire.

Alors que la première génération de cartes géologiques à échelle régionale en Australie reposait sur la photographie aérienne, la deuxième génération repose sur des levés magnétiques et radiométriques aéroportés systématiques et de grande qualité. En manipulant les données ainsi obtenues, à l'aide de techniques de traitement des images, les géoscientifiques peuvent cartographier, non seulement l'assise rocheuse, mais aussi le régolite et l'assise rocheuse qu'il dissimule, avec une rapidité et une rentabilité qui étaient encore impossibles il y a peu de temps. Cette approche permet de repérer rapidement les erreurs dans les cartes de première génération, mais, plus encore, elle permet souvent de repérer des caractéristiques importantes que l'on n'avait pas soupçonnées ou imaginées auparavant. Vu l'évolution des techniques de modélisation et d'inversion géophysiques, on s'attend à voir ces fichiers prendre de plus en plus d'importance dans la production de modèles géologiques tridimensionnels robustes de l'écorce, notamment quand on les inverse conjointement avec d'autres données géophysiques comme celles qui proviennent de levés gravimétriques et sismiques. La connaissance du régolite progresse rapidement, car aux études traditionnelles sur le terrain viennent s'ajouter les résultats des levés radiométriques aéroportés, ainsi que des levés faits par radiomètre multispectral à balayage installé à bord d'avions et de satellites.

Un autre horizon important est l'incorporation de la dimension temporelle pour la création de modèles quadridimensionnels. Les progrès de la géochronologie permettront de faire avancer de nombreux domaines des sciences de la terre, par exemple la stratigraphie séquentielle, où on a besoin d'une plus grande précision de datation; la gîtologie, où on a besoin de mieux dater les processus de minéralisation; et la géoscience environnementale, où on a besoin de mesurer le rythme des changements naturels pour mieux comprendre les changements anthropiques. Un progrès technologique qu'il convient de mentionner en particulier dans le domaine de la géochronologie est la mise au point de microsondes ioniques comme SHRIMP. Ces outils de datation efficaces commencent maintenant à avoir des retombées considérables sur la stratigraphie séquentielle et sur les études de gîtologie.

Il est peu probable que l'efficacité de ces nouvelles approches soit limitée par la technologie. Certains faits semblent plutôt indiquer que c'est la pensée géologique conceptuelle qui freinera les progrès, parce que les géoscientifiques en viennent à dépendre de plus en plus de la puissance des ordinateurs pour produire des images géoscientifiques et des modèles géologiques spectaculaires, et accordent moins d'attention à la géologie sur le terrain et à l'importance de l'intuition scientifique dans la formulation de nouveaux concepts géoscientifiques. Les systèmes d'information géographique offrent le moyen de relever ce défi, mais il faut s'assurer que ceux qui utilisent ces outils ont des connaissances géoscientifiques suffisantes pour tirer le plus grand parti de la technologie.

Sur le plan du développement durable, le plus grand problème qui se pose aux géoscientifiques, notamment à ceux qui travaillent pour des commissions géologiques, est de savoir comment présenter leurs interprétations des données et leurs concepts d'une fa(on que puissent saisir rapidement et avec précision les décideurs et tous ceux que toucheront les décisions prises. Si les résultats ne sont pas d'un abord facile, il est à craindre qu'on négligera la valeur des données géoscientifiques dans l'aménagement du territoire et la gestion des ressources.

It is a great pleasure to participate in this International conference to celebrate the 150th anniversary of the Geological Survey of Canada. On behalf of Australia's sister organization, the Bureau of Mineral Resources (BMR), I'd like to congratulate the GSC on achieving such an important milestone, and to wish the staff of the Organization every success in their future endeavours as members of one of the world's truly great national geological surveys.

Compared to the GSC, the BMR is a relatively new organization that dates back to 1946. BNM's newness was obviously at the back of Chris Findlay's mind when he invited the BMR to present this paper on New Frontiers and Technologies. In his invitation Chris suggested that we should deal with "New Frontiers" in the knowledge sense, and with "New Technologies" in the sense of the tools required to generate or apply such new knowledge.

I will begin with a brief overview of some of the new knowledge frontiers that are confronting geological surveys today. Next I will examine how these frontiers are being crossed with the help of a combination of proven geoscientific data acquisition techniques and new computer-based technologies, and finally I will spend a few minutes discussing some emerging priorities for future work by national geological surveys.

Of the various knowledge frontiers facing geological surveys, some of the most important are those arising from the concept of sustainable development. The concept has emerged as a major issue over the last two decades because of growing concern about the effects that humankind is having on the environment. The idea of development at any cost no longer meets with universal approval, and more and more we are seeing increasing attention being paid to conservation and environmental protection.

The contrasting demands being placed on geological surveys by resource development on the one hand, and by environmental management on the other, have already been examined at length today, and I do not plan to discuss them further. Rather, what I want to do is focus on the core business of geological surveys, which is the acquisition and interpretation of the various geoscientific data sets that are necessary for both the discovery and management of resources, and the conservation and management of the environment. In the former case data sets are assembled as a basis for understanding the geology of the earth's crust and its endowment of resources, while in the latter case they are collected to help elucidate the earth's surficial geology and the way it interacts with the biosphere, atmosphere, and hydrosphere.

In recent years there have been many important advances in the way geoscientists acquire, manipulate, and interpret data, and most of these can be attributed to the great improvements that we are witnessing in the performance of computers. Chris Findlay, in his invitation to present this paper, acknowledged that "New Frontiers and Technologies" is obviously a very broad topic in the context of the whole of the earth sciences. He therefore suggested that this paper should be selective, and should focus on those frontiers and technologies with which the BMR has a particular interest.

In keeping with his suggestion, the remainder of this paper will have a distinctly Australian flavour, and I will use recent results from Australia's National Geoscience Mapping Accord to illustrate how the task of regional-scale geoscience mapping is being revolutionized by computers and other new technologies to accelerate our understanding of the Australian continent.

The methodology of the National Geoscience Mapping Accord dates back to 1988 when our mineral exploration industry noted during the Woods Review of the BMR that if Australia was to maintain its competitive position as a mineral producer, one thing we needed to do was overhaul the geological foundation on which our mineral exploration is based. It was argued that while the existing first generation 1:250,000 scale geology maps had served Australia well, they were aging and their usefulness was declining. Industry argued further that because of the increasing likelihood that yet-to-be discovered deposits would be concealed beneath the surface, it would be necessary to produce a second generation of geology maps that went far beyond a simple revision of the existing maps. It was suggested that the new mapping should include the third dimension of depth, and that a particular effort should be made to elucidate the bedrock geology of the extensive tracts of prospective ground in Australia that are covered by regolith, that is, by weathered, in-situ and transported material.

A good example of the extent of Australia's deep-weathering frontier and typical surface expression of the frontier are to be found in the Archean Yilgarn Terrain in Western Australia. This Terrain is highly prospective for gold, nickel, copper and zinc and substantiates the simple message from industry: "Break the regolith barrier!"

As Dr. Playford noted elsewhere in these Proceedings, the Woods Review acknowledged the importance of strengthening geological mapping in Australia. The development of a National Geoscience Mapping Accord between the BMR and the state and territory geological surveys was thus recommended to achieve that goal.

The NGMA, as the Accord is now called, was started in 1990. Its objectives are:

- to optimize the environment for mineral and fuel exploration through the provision of geoscientific data, maps, and reports;
- to provide a reliable base for the assessment of undiscovered mineral and fuel resources; and
- to strengthen the geoscientific foundation as a basis for the provision of sound environmental and land-use decision making.

To be successful in meeting these objectives the NGMA cannot rely solely on the methodologies used to produce the first-generation maps. At best, such an approach would simply lead to second editions of the existing maps. To meet the challenges like the regolith barrier, the NGMA partners have adopted an approach pioneered by the exploration industry in Australia to tackle the same challenges on the more local scale of an exploration tenement. The basis of their approach was the underpinning of field-based studies with high-quality systematic airborne geophysical surveys involving the simultaneous collection of both magnetic and radiometric data. The use of such airborne geophysical survey techniques to aid mapping and exploration is not new, but what is new and what has really enhanced their usefulness by orders to magnitude has been the employment of powerful image processing systems to display, manipulate and interpret the geophysical data.

A BMR aircraft is being used along with contract aircraft to collect new data to the NGMA specification of an altitude of 100 m and a line space of 400 m. A gravity image of Australia has been generated using BMR's gravity data base that presently has a station spacing of around 11 km.

The real value of combining geophysical survey data and image processing is, to quote the old adage, "A picture is worth a thousand words." The approach provides geologists and geophysicists with a powerful means of communication that is fast removing the barriers between geology and geophysics. However, just as importantly, the approach is also facilitating communication between geoscientists and non-geoscientists, and I believe it offers great potential for introducing geoscientific arguments into larger issues such as the debate on land use planning and environmental management.

From a purely technical viewpoint, other important benefits of the geophysics/image processing approach are that data acquisition is non-invasive and rapid, and outputs can provide geological insights that would be difficult, if not impossible, to gain by other means.

We are finding with the Accord that magnetics are particularly helpful in delineating bedrock geology, both in areas of outcrop and under cover, while radiometrics are proving very useful, firstly for delineating bedrock geology in areas of outcrop, and secondly and most importantly for mapping and understanding the regolith.

To illustrate the great power of the NGMA methodology, I would like to discuss a few examples from the Lachlan Fold Belt NGMA Project. This project is being undertaken by the BMR and the Geological Survey of New South Wales. The geophysical data set was collected last year by the NGMA partners in collaboration with a private contractor, GEOTERREX. The survey covers the Bathurst 1:250,000 map-area, the eastern boundary of which lies only 100 kilometres west of Sydney. This area, which extends 140 km from east to west and 100 km north to south, is of great historical importance because it is the district where the first major gold discovery was made in Australia in 1851. That discovery led to the first Australian gold rush, and mineral exploration, discovery and mining have continued in the area until the present. The area is geologically interesting and has long been a favourite for study by the staff and students of nearby universities in Sydney and Canberra, as well as by the staff of the BNM and the New South Wales Survey.

In 1968, the first generation 1:250,000 geology map was published for the Bathurst area. Thus, it would not be unreasonable to conclude that the geology of the area is well understood. However, much remains to be learned and this process is being implemented through application of NGMA methodology.

The geology of the Bathurst area is characterized by extensive areas of north - south striking, tightly folded Ordovician, Silurian and Devonian sediments and volcanics with abundant intrusions of S-type Silurian granites and I-type Carboniferous granites. Tertiary basalts occur extensively in the northwest quadrant of the map-area and extend to localities in the southeast quadrant.

Recently acquired magnetic imagery highlights key elements of the geology of the Bathurst map-area, including the Carboniferous I-type granites and a prominent belt of Ordovician andesites in the southeastern part of the area. In a complementary manner, radiometric imagery highlights the potassium-rich I-type granites, areas of Tertiary basalts and their derived regolith that are low in potassium and the folded Silurian and Devonian siltstones, shales and tuffs of the northwestern part of the map-area.

In general terms the radiometric imagery reflects the mapped bedrock geology so well that two important conclusions can be drawn. The first is that most of the regolith is derived from bedrock weathered in situ. The second conclusion is that the intensity of weathering is low. Both conclusions are consistent with the erosional landforms of the area and are important for planning both landcare and mineral exploration strategies.

The Bathurst area provides further examples of the benefits of second generation mapping which includes the integration of both new and previously available data and information. Within the area are granite plutons of Silurian age intruded into Ordovician andesites that are highly magnetic. On either side of the andesites are Silurian granites and volcanics of low magnetic susceptibility which produce a sharp magnetic boundary between these rock masses. This boundary was not discovered during first generation mapping but it is one of considerable exploration significance. Recent investigations have discovered a zone of highly-altered Silurian volcanics associated with the boundary. These Silurian volcanics are known from experience elsewhere in southeast Australia to be very prospective for volcanogenic massive sulphide deposits.

Radiometric data for the Bathurst area are also proving to be particularly useful for distinguishing differences between and within rock types which had not been previously possible on the basis of geological observation alone. These radiometric data have enabled distinctions to be made between volcanic rocks of different ages and the separation into distinct components of granitic plutons previously mapped as a single pluton. This information has also provided new insights on the emplacement history and differentiation of granitic plutons.

A second NGMA example is provided by the North Queensland Project that is located on Australia's remote northern Cape York Peninsula. This Accord project involves the BMR and the Geological Survey of Queensland and my examples are drawn from the Ebagoola map-area which covers the southern part of the geological province known as the Coen Inlier.

The first generation 1:250,000 scale geology map for Ebagoola, which covers an area having dimensions of 165 km from east to west and 110 km from north to south, was published in 1977.

Important features of the map-area are a central zone comprising three prominent belts of north-south trending metamorphic rocks separated by Paleozoic granites with extensive areas of Tertiary and younger sedimentary rocks to the east and west of the central igneous and metamorphic complex.

Until 1991 the three metamorphic belts were thought to be of Proterozoic age. Recent age-dating work by BMR, however, indicates that they are, like the adjacent granites, of Paleozoic age. The Paleozoic geology of the Ebagoola area is therefore similar to that for the Bathurst area except for the regolith of the Ebagoola area which is much more complex.

Radiometric imagery for the Ebagoola area has been particularly useful in providing data to aid in the interpretation of the regolith which is closely related to the physiographic development of the map area. In terms of physiography the area comprises three main zones. These are: the central uplands region; the eastern coastal plain; and, the western plain.

The central uplands region is an erosional landform much of which is covered by deep residual material formed by in situ chemical weathering. Little other than residual quartz now remains in the regolith. In the absence of potassium, thorium or uranium in this material, the regolith produces essentially no radiometric response. In contrast, a strong radiometric response is obtained from areas in which active stripping of the regolith has occurred, thereby exposing fresh granitic material containing abundant potassium feldspar.

On the eastern coastal plain, depositional processes dominate. Sediments derived from the granite and metamorphics to the west form broad alluvial outwash fans and braided stream deposits. Along the coast these sediments have been reworked by tidal and wave action and deposited as beach ridges and chenier plains. The distribution and origin of the sediments of the eastern plain are recorded in the imagery by the high potassium response that indicates a granite source and the high-thorium response that reflects a metamorphic source.

In contrast to the other two provinces, the western plain is an area of some stability characterized by various kinds of paleoforms that reflect a long history of deep weathering. Low potassium and relatively high thorium counts within the province are associated with deeply weathered sandy soils. Deep weathering residual plateaus are surfaced by bauxite or pisolitic iron material. They show well in imagery because of a strong thorium signature that reflects minerals resistant to weathering such as monazite. Rivers flowing westwards across the western plain are clearly visible on the imagery because they contain abundant relatively fresh radiometric material that is being stripped from the central uplands.

The coastal plain and central uplands are separated by a prominent 200 m high escarpment. This escarpment is actively retreating westwards, and rivers that previously flowed westwards are being captured and their flow diverted to the east. Points of capture are characterized by rapid down-cutting and regolith-stripping.

To summarize, strong radiometric responses represent sites of exposed bedrock and active erosion, whereas weak responses are indicative of sites of abundant deeply-weathered material. Thus, radiometric imagery can be used to map geomorphic activity and as such has great potential for land degradation studies, allowing geoscientists to rapidly map areas of erosion and soil thinning.

I previously noted that age dating by BMR had yielded a Paleozoic age for the metamorphic rocks on the Ebagoola sheet. The fourth dimension of time is another major frontier for our mapping accord. The Sensitive High Resolution Ion Microprobe, SHRIMP 1, underpins our dating studies. It was developed by Dr. W. Compston and his colleagues at the Australian National University in Canberra. SHRIMP 1 is supported jointly by the University and the BMR and is used mainly for zircon dating.

Because of the small area of analysis, and the fact that several hundred zircon grains can be placed on a single SHRIMP sample mount, SHRIMP is a very versatile and efficient dating instrument. Two more SHRIMPS are presently under construction. One will be used to expand the ANU/BMR operation in Canberra, and the other will be located in Perth where it will be dedicated to western Australian geochronology and run by a consortium of Perth universities and the Geological Survey of Western Australia.

We are still a long way off fully utilizing the geophysical data I've been describing. Considerable work remains to be done in the area of geophysical modelling and inversion. Inversion of the magnetic data, either alone or jointly with other data sets such as gravity and seismic is a priority whose ultimate objective should be the construction of the robust three dimensional models that will aid key geological survey activities such as exploration support, mineral resource assessment, and land use planning.

The full potential of radiometrics as a mapping tool has yet to be realized. It is obvious from our work on Ebagoola that radiometrics will be a boon for regolith mapping. Trials to determine how best to do this are underway in several NGMA areas in addition to Ebagoola, and I'm optimistic that radiometrics will have an increasing impact on future mapping. The collection of data for radioactive elements other than potassium, thorium, and uranium might also be worthwhile and should be investigated.

Mapping should not be regarded as an end in itself. Rather, it is an activity that provides the geological insights into the various geological-survey roles I've just mentioned. Geographic Information Systems or GIS which can rapidly overlay and manipulate a variety of different data sets are going to play an increasing role in these endeavours. I believe they will be a powerful tool for helping geological surveys overcome one of their greatest obstacles which is the presentation of their data, interpretations and concepts in ways that can be quickly and accurately understood by decision makers and those affected by their decisions.

Unless our outputs can be appreciated by people other than geoscientists, there is a greater danger that the geological underpinnings of sustainable development will be neglected.

[editor's note. This paper has been adapted by the Geological Survey of Canada on the basis of a transcript of the author's oral presentation.]

Geologic Hazards in Japan

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Abstract

One of the aspects of industrialization is the huge concentration of population and human activities in several megalopolises. Greater Tokyo area is a typical example of such cities with many important functions of a nerve centre of modern society, such as central government, business and financial centres, hubs of traffic and communication, and research and cultural activities.

Tokyo has become more vulnerable to geologic hazards, especially earthquakes, due to this concentration and complicated integration of communication networks and computer controlled facilities. The estimated social and economic loss is increasing for the same scale of natural disruption; or in other words, a smaller scale earthquake has become of greater concern to authorities.

The measures taken by the central and local governments to mitigate hazards of potential earthquakes in the Tokyo area include earthquake prediction, earthquake-resistant and fireproof construction, and emergency social regulations. There are two types of earthquakes that the prediction efforts have to address; the huge earthquake of magnitude eight (M8) which is predicted in the Tokai area 180 km south east of Tokyo and the smaller earthquakes (M6-7) expected within the Greater Tokyo area. There are prediction theories for the huge earthquake which is expected along the boundary between the Philippine plate and the Japanese island, and monitoring facilities have accordingly been set up for any precursor quakes. Problems still remain for the smaller earthquakes, although the risk of them is still devastating to the cities nearby. Possible locations of these types of earthquakes have not been identified yet, because precursor shocks are too small to be detected with existing monitoring facilities. The size of the aftershock area of an earthquake at M7 is 50 km, and that of M6 is only 16 km. This small size makes the problem very difficult to deal with.

The responsibility of the Geological Survey of Japan in this context is limited to geologic processes. Our activities comprise mapping of active faults in earthquake prone areas, real time monitoring of ground water geochemistry, historical seismology, and experimental petrophysics. These activities are coordinated with those of other government agencies to make these efforts part of the national endeavour for earthquake prediction.

International cooperation in many of these fields will be mutually beneficial and will help promote better understanding of geologic processes.

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Résumé

L'un des aspects de l'industrialisation est la très forte concentration de la population et de l'activité humaine dans plusieurs mégalopoles. La région métropolitaine de Tokyo est un parfait exemple de ce genre de villes, où sont réunies un grand nombre des importantes fonctions du cerveau d'une société moderne : siège du gouvernement central, centre des affaires et centre financier, plaque tournante des transports et des communications, centre de la recherche et des activités culturelles.

Cette concentration et cette intégration complexe des réseaux de communication et des installations informatisées ont rendu Tokyo plus vulnérable aux dangers géologiques, en particulier aux séismes. On estime qu'une même intensité de séisme causerait des pertes sociales et économiques de plus en plus lourdes. Autrement dit, les autorités s'inquiètent plus qu'avant des dégats que peut causer un petit séisme.

Les mesures prises par les autorités centrales et locales pour réduire le danger que peuvent représenter les séismes dans la région de Tokyo comprennent la prédiction des séismes, la construction de bâtiments parasismiques et à l'épreuve du feu, ainsi que des mesures de protection civile. Les efforts de prédiction doivent porter sur deux types de séisme : les grands séismes de magnitude 8 (M8), que l'on prédit pour la région de Tokai, à 180 km au sud-est de Tokyo, et les plus petits séismes (M6-7) prévus dans la région de Tokyo. Il existe des théories de prédiction du grand séisme, qui, pense-t-on, devrait se produire à la limite entre la plaque des Philippines et le Japon. On a donc installé des instruments de surveillance pour guetter tout séisme précurseur. Il reste des problèmes dans le cas des petits séismes, qui, malgré leur plus faible intensité, risqueraient de dévaster les villes voisines. On n'a pas encore établi où ces séismes risquent de se produire, parce que les chocs précurseurs sont trop petits pour être détectés par les instruments en place. Les répliques d'un séisme de magnitude 7 s'étendent sur une distance de 50 km, tandis que celles d'un séisme de magnitude 6 ne s'étendent que sur 16 km. C'est cette petite envergure qui rend le problème particulièrement difficile.

Dans ce contexte, la responsabilité de la Commission géologique du Japon se limite aux processus géologiques. Nos activités comprennent la cartographie des failles vivantes dans les zones sujettes aux séismes, la surveillance en temps réel de la géochimie des eaux souterraines, la sismologie historique et la pétrophysique expérimentale. La coordination de ces activités avec celles d'autres organismes du gouvernement vise à faire de ces efforts un élément du programme national de prévision sismique.

La coopération internationale dans un grand nombre de ces domaines profitera à tous et contribuera à une meilleure compréhension des processus géologiques.

INTRODUCTION

It is a pleasure to speak at the GSC's special conference. I would like to say thank you to the Geological Survey of Canada for providing this occasion.

Geologic hazards and global environmental problems are separate issues to be addressed within different disciplines of the geosciences. However, both these problems arise at the interface between growing human activities and the Earth, and share some common characteristics. Solutions will not be found in geoscience only but in an overall design of human activities on the Earth. The ultimate causes of these problems are in many cases out of man's control, such as the geologic hazards of earthquakes and volcanic eruptions. At present, it also appears that environmental problems such as population explosion and everyone's aspiration for development are beyond our control. What is expected from the geosciences are more precise data leading to a sound scientific understanding of the Earth. The key topic of this report is "The 21st Century must become the Century of the Earth".

The Geological Survey of Japan (GSJ), like many geological surveys in the world, is responsible for geologically related topics such as natural resources and the environment. A new approach is now under review in GSJ to meet the changing role of the Geological Survey as we move towards the 21st century. This report deals with the present situation and GSJ's role in the studies of geologic hazards related to earthquakes and volcanic eruptions in particular. We believe that the problems GSJ is involved with should be common to many geological surveys.

Expansion of human activities in Japan is characterized by expansion of the area of industrial and housing development into geologically dangerous zones, rather than an increase in net population. One of the aspects of industrialization is the massive concentration of population and human activities into several megapolises. The Greater Tokyo area is a typical example of such cities which contain many important functions and act as the nerve center of modern society, including the central government, business and financial centers, hubs of traffic and communication, and research and cultural activities. Tokyo has become more vulnerable to geologic hazards, especially earthquakes, due to this concentration and complicated integration of communication networks and computer-controlled facilities. The estimated social and economic loss is continuing to increase for a given size of natural disruption, with smaller scale earthquakes becoming of greater concern to authorities.

The measures taken by the central and local governments to mitigate hazards of potential earthquakes in the Tokyo area include earthquake prediction, earthquake-resistant and fireproof construction, and emergency social regulations. There are two types of earthquakes the prediction efforts have to address: first, the huge earthquake of magnitude eight (M8) which is predicted for the Tokai area 180 km southwest of Tokyo, and second, smaller earthquakes (M6-7) expected within the Greater Tokyo area. There are prediction theories for the huge earthquake which will eventually occur along the plate boundary between the Philippine Sea Plate and the Japanese Islands, and monitoring facilities have been established to detect any precursors. Problems still remain with regards to the more frequent and smaller earthquakes.

Possible locations of M6-7 earthquakes have not been identified yet. Even if precursors exist, the high noise level caused by human and industrial activities may make the detection extremely difficult.

GSJ is involved in the prediction program related to both types of earthquakes in the Tokyo area.

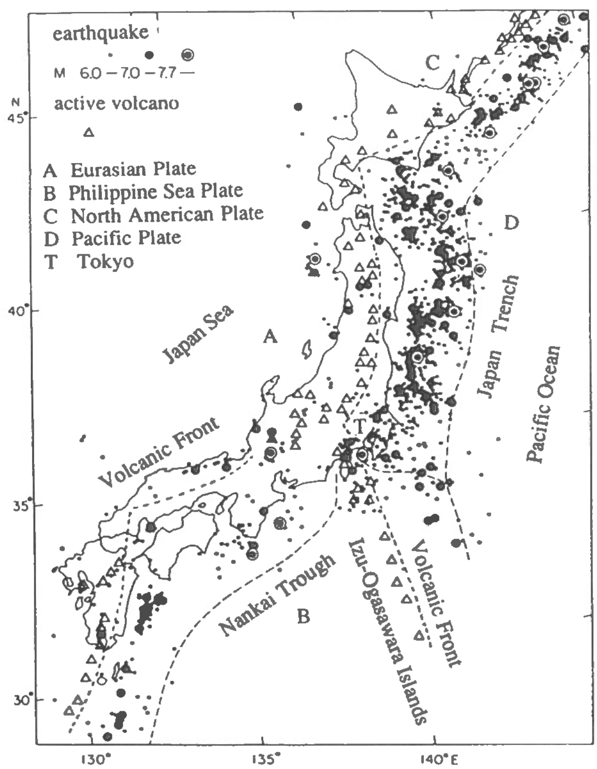
Japan suffers from volcanic hazards as well. There are 77 volcanoes in Japan classified as "active", with activity ranging from ongoing eruptions through that restricted to fumaroles and volcanic tremor, all the way to now quiet volcanoes with historical eruptions. Many volcanoes are located close to densely populated areas, industrial zones, and major traffic and communication lines. For instance, the industrialization of the Tokai-do (Tokyo-Shizuoka) region was achieved without due consideration to potential volcanic hazards related to Japan's largest volcano, Mt. Fuji, which is located only 20 km away.

The responsibility of the Geological Survey of Japan in this context is limited to geologic processes. Our activities comprise mapping of active faults in earthquake-prone areas, geological mapping of active volcanoes, real-time monitoring of ground water geochemistry of the Tokai area and of displacement of Unzen Volcano on Kyushu Island, historical seismology and volcanology, and experimental petrophysics. These activities are coordinated with those of other governmental agencies to integrate these efforts with the national endeavours for prediction of earthquakes and volcanic eruptions.

OUTLINE OF THE GEOLOGICAL SETTING OF THE JAPANESE ISLANDS WITH REFERENCE TO EARTHQUAKES AND VOLCANOES

The Japanese Islands are located on the Circum-Pacific tectonic belt where earthquakes and volcanoes accompany the subduction of plates. There are two trench-arc systems associated with the Japanese Islands. A critical aspect is collision of the region of the Izu-Ogasawara Islands on the Philippine Sea Plate with the mainland just south of Mt. Fuji. From this point northwards the plate boundary extends on land. The relative movement is especially complicated in the area around Tokyo, where four plates are interacting with each other. These are the Pacific, Philippine Sea, Eurasian and North American Plates (Figure 1).

Figure 1: Earthquakes and volcanoes in and around the Japanese Islands. (modified from Utu, 1982)



EARTHQUAKE AND VOLCANIC ERUPTION PREDICTION

Tokai Earthquake and Greater Tokyo Earthquake

The Tokai Earthquake, expected to occur southwest of Tokyo along the Nankai Trough, is the most urgent target of vigilant observation and prediction. This expected earthquake will be of the interplate-type (Philippine Sea Plate and Eurasian Plate). Recurrent earthquakes of magnitude eight (M8) class have been recorded in the past in this area, most recently in 1946. Estimates of the frequency of earthquakes, presence of regions lacking recent large earthquakes, observed land deformation, the expected magnitude of the earthquake, and proximity to large cities, all contribute to the present level of awareness and expectation.

Greater Tokyo is a sprawling urban area including four large cities located on the Kanto sedimentary basin with a population exceeding thirty million. The earthquake in 1923 reduced Greater Tokyo to ashes and killed 99,333 people. Although the hypocenter of the 1923 earthquake was 60 km to the south, the area was completely destroyed due to the cities being constructed on soft formations.

It is believed this area will suffer more seriously from the expected Kanto earthquake than the former one in 1923 because of the great increase in population and modern facilities such as subsurface gas supply lines, underground rail ways, tall buildings, and the decrease of vacant space to serve as zones of safety. Some reports anticipate several hundred thousands of victims.

Earthquake Prediction Program and the Role of GSJ

The Japanese government is making efforts to predict earthquakes which may affect the Greater Tokyo area in the near future. Table 1 shows the main organizations related to the national earthquake prediction program. Under the Prime Minister, who is responsible for issuing an earthquake warning statement, six ministries and their research institutes are organized to carry out the earthquake prediction program.

Table 1. Main organizations related to earthquake prediction in Japan.

Prime Minister - Issues The Earthquake Warning Statement
- Headquarter for Promotion of Earthquake Prediction
- Geodesy Council (The National Prediction Program)
  - Prime Minister's Office
    * National Research Inst. Earth Sci. & Disaster Prevention
    * National Land Agency
  - Ministry of Home Affairs
    * Fire Department Agency
  - Ministry of Construction
    * Geographical Survey Institute
  - Ministry of Transportation
    * Meteorological Agency
    * Maritime Safety Agency
  - Ministry of International Trade and Industry
    * Geological Survey of Japan
  - Ministry of Education(Bureau of Geodesy Council)
    * National Universities
    * National Astronomical Observatory

The earthquake prediction program is classified into the following three categories:

(1) Observation and research for long-term prediction;
(2) Observation and research for short-term prediction;
(3) Fundamental research in earthquake prediction and the development of new technology.

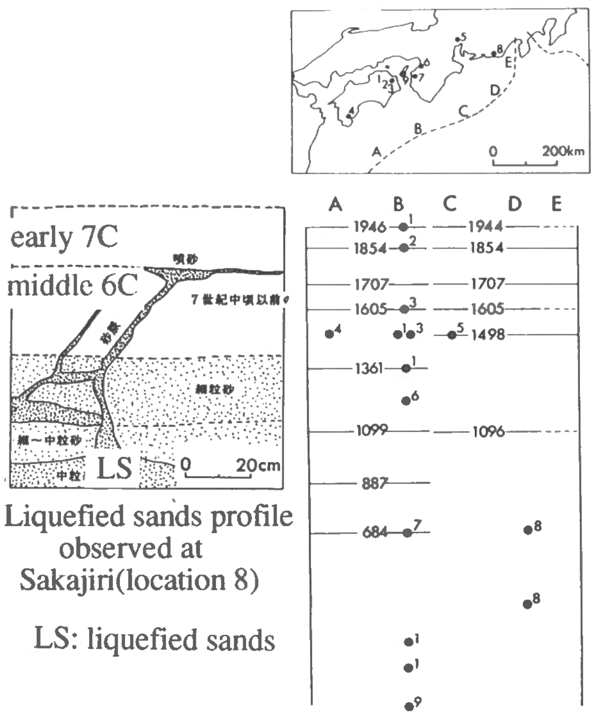
Long-term prediction includes geodetic, seismological, tidal, and geomagnetic observation, mapping of active faults and deformations, and historical surveys of past earthquakes.

Short-term prediction covers monitoring of the changes of crustal movement, seismicity, the gravity and geoelectromagnetic fields, and gas geochemistry and ground water level in boreholes.

Fundamental research includes rock mechanics, crustal stress measurements, and in-place physical properties of the crust.

Figure 2 shows the result of historical surveys of past earthquakes (Sangawa, 1992) Scientists of GSJ developed a new geological method to determine the age of past earthquakes by observing the record of liquefied sands at various sites. Based on the combination of geological and radiometric approaches, precise ages of major earthquakes occurring in the last 20 centuries in western Japan have been determined. The table of earthquake chronology provides information useful in the prediction of future earthquakes in certain areas.

Figure 2: Example of earthquake chronology by liquified sand method.



In another approach to long-term earthquake prediction, the location and nature of active faults gives valuable information necessary to assess the probability of earthquakes in a given area. GSJ has covered the Japanese Islands with mapping of active faults at the scale of 1:500,000.

GSJ has begun the application of modern technologies such as reflection seismic profiling to detect buried active faults in areas of active sedimentation. In the Tokyo Bay area, a series of sediment-covered young faults trending north-south is beneath the bay (Sugiyama and Endo, 1992).

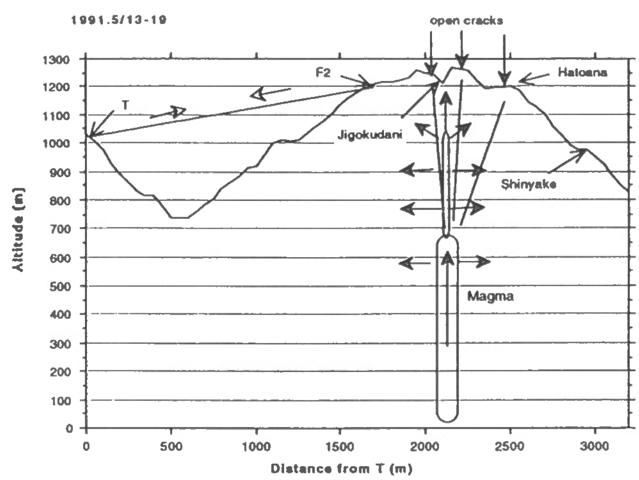
Volcanic Eruption Prediction and the Role of GSJ

In contrast to earthquake prediction, for which the Prime Minister holds responsibility, the prediction of volcanic eruptions is a matter for local government and academic societies. The reason for this is that the scale and area affected by volcanic eruptions is imagined to be smaller than that related to earthquakes. Small budgets and a weak system for the prediction of volcanic eruptions is reflected in this governmental attitude. However, these aspects become a matter of controversy whenever a volcanic disaster occurs.

GSJ has carried out geological mapping of major active volcanoes and has succeeded in establishing the eruption histories of several volcanoes. In addition to research aimed at long-term prediction, such as geological mapping, application of new technology to short-term prediction is also being attempted. EDM (Electronic Distance Measurement) was applied to the Unzen Volcano, which started activity in late 1990. A GSJ team established a network of EDM stations surrounding Unzen Volcano in early May,1991. From May 10, 1991, the distance along the baseline between station F2 (top of Mt. Unzen) and T1 (1.6 km south of F2) continuously decreased. The amount of shortening reached 20 cm (0.0125%) 5 days later (May 16). This shortening was interpreted to be the result of upward migration of the magma chamber (Figure 3).

A warning of impending eruption was sent to the Meteorological Agency and the Committee for Volcanic Eruption Prediction. Four days later (May 20), the first appearance of the lava dome was observed. On May 24, the first large-scale pyroclastic flow reached the city of Shimabara located 8 km east of Mt. Unzen. As a result of the evacuation order issued, there were no victims at that time. However, an unexpectedly larger pyroclastic flow swept through villages on June 6 and killed 43 people, including three volcanologists, one American and two French. The previous eruption of Mt. Unzen in 1792 killed more than 15,000 people living in the Kumamoto

Figure 3: An interpretation of the displacement of Mt. Unzen caused by upward migration of magma chamber.



area 40 km east of Mt. Unzen, as well as those in the Shimabara area. If the scale and phenomenon of the present eruption were the same as that in 1792, it is estimated that the scale of disaster might have reached 10 times greater than in 1792 due to the large increase in population inside the area. The eruption has been continuing a constant level of activity for the last two years with a possibility for escalation in the size of eruptions. GSJ is continuing EDM monitoring, with real time data transfered to the main office of GSJ in Tsukuba via telemetry.

The basic role of GSJ is in volcanic hazard assessment and long-term prediction rather than monitoring and short-term prediction, due to the nature of our disciplines. However, basic study on the development of new technology such as EDM, useful for short-term prediction, is also a matter of our concern.

INTERNATIONAL COOPERATION

The roles of earth scientists will become more and more important in the 21st Century in predicting, preventing and mitigating disasters associated with geological processes. To achieve our mission, international cooperation among countries sharing similar geological settings is required in order to exchange experience, transfer technology, and promote training, all of which will help everyone to cope with the problems we now share, not to mention problems we have not yet foreseen.

We conclude this report stressing our key word "International Cooperation", as this is essential to face the coming 21st Century, both in terms of geologic hazards and environmental concerns, such that we all might live more in harmony with the Earth we share.

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Theme IV Discussion:

D.L. Peck: My impression is that in the US, and perhaps in Japan too, there may be even more loss of life and certainly more loss of property from landslides and debris flows than from eruptions and earthquakes. Do you have programs with respect to landslides and debris flows?

K. Ogawa: Yes. The most dangerous landslide is accompanied by volcanic eruptions. In the case of Unzen, about 200 years ago, the number of people killed by the magma itself was very small, but almost all the people were killed by a very large-scale landslide. So we are especially studying landslides associated with volcanoes.

H. Czichos: What is the physical phenomena or mechanism by which you can detect such a phenomenon four days in advance?

K. Ogawa: As the magma chamber is migrating upward, the mountain is moving due to the intrusion of magma. We observe the distance between fixed points on the top of the mountain. Shortening of the distance between the points starts due to the upward migration of magma.

A. Darnley: Regarding the utility of radiometric methods in Australia, given the usefulness of three elements in providing additional information about the surface and the regolith, given that radiometric methods are a physical technique that provide geochemical information, and given the usefulness of those three elements, are there any plans on the part of BMR to implement a multi-element geochemical survey in Australia to supplement their available data base?

N. Williams: An activity of the new mapping accord projects is a systematic stream sediment geochem program of reconnaissance scale, about every 10 km. The first public release of that new generation of stream sediment geochem is just being released for the Cape York project area.

E. Zen: In electric study do you look at the depths of the regoliths and the history of the evolution of the soils?

N. Williams: The radiometric work I described has been used as the foundation for a lot of field studies on the Regolith. We are focusing mostly on the bit under the soils rather than the soils themselves. The CSIRO maintains the main federal government soil mapping activity but we're trying to provide the geological underpinning of the soil work. We've just initiated a big pilot program in Central New South Wales where CSIRO (New South Wales Soil Conservation people) and ourselves are jointly mapping an area. We're getting the geology, the regolith, the biosphere, the hydrosphere, etc. We rely on drilling from companies, etc. to give us depth. We are not using electrical methods as such on the ground to do any detailed mapping.

THEME V: INTERNATIONAL COMMUNICATION, COOPERATION AND COLLABORATION

International Non-governmental Cooperation in the Solid Earth Sciences

U.G. Cordani and R. Brett

IGCP The International Geological Correlation Programme: past and future

A.J. Naldrett

Discussion

International Non-governmental Cooperation in the Solid Earth Sciences

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Abstract

Science is the best field of human activities for international cooperation, since its mission is to create and develop new knowledge, which then belongs to mankind; in this sense, it has a universal transnational character. The Earth Sciences, in addition, have a built in strong regional component, because their development requires observations and measurements in all parts of the world, followed by complete communication and exchange of information. The needs for international cooperation are obvious.

There are two main structures for international scientific activities. One of them is governmental, related to the United Nations, where scientific cooperation is mainly dealt with within UNESCO. The other is non-governmental, and related to ICSU, the International Council of Scientific Unions. ICSU comprises 20 scientific unions, dealing with specific fields, three of which belong to the Earth Sciences: IUGG (International Union of Geodesy and Geophysics), established in 1919, IGU (International Geographical Union) formed in 1922, and IUGS (International Union of Geological Sciences) organized in 1961.

The aims of IUGS include the encouragement of research on geological problems of fundamental or applied character, and the promotion of international inter-disciplinary cooperation in geology and related sciences. The scientific activities of the Union are carried out by international committees or commissions (Stratigraphy, Tectonics, etc.) or by affiliated organizations and autonomous international associations or societies such as INQUA, IAEG, AGID, IAGC, SEG, etc.

IUGS, similarly to the other sister Unions, and ICSU itself, does not perform actual research, but allows the scientific community to accomplish activities otherwise impossible (or very difficult) without adequate international organization. It provides only seed money for the necessary coordinating meetings, in which exchange of scientific information, planning of research, and discussion of data and interpretations, are made.

More and more, in recent years, geology has acquired a global perspective because of the unifying model of plate tectonics and because of the new concept of treating the earth as a complete system whose parts are inter-related. Among the successful international programs of global perspective involving the Earth Sciences, are the International Geophysical Year (late 50's), the Upper Mantle Program (60's) and the Geodynamics Projects (70's). The latter two were run in partnership between IUGG and IUGS as inter-union programs. Their successor, the International Lithosphere Program, started in 1981 and is entering a new phase in the 90's which promises great achievements.

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IUGS also promotes research activities together with UNESCO. Its main purpose in this respect is the International Geologic Correlation Program, started in 1972 and still successfully continuing. In addition, IUGS collaborates also in some of the major interdisciplinary programs, such as the ICSU International Geosphere-Biosphere Program (Global Change) and the International Decade for Natural Disaster Reduction, for which there is also a strong UNESCO component.

Since the international organizations provide only scientific coordination, the research is carried out by scientists in their own institutions and thus the participation and support by national organizations is essential. In many countries, the geological surveys are the strongest organizations in geological research, especially in the Third World, where academic institutions are usually not well developed. Reciprocally, the international experience through effective participation in international programs may greatly benefit the geological surveys because of the exchange of personnel and information, which leads to improved interpretations of the regional and global problems.

Résumé

De tous les champs d'activité humaine, la science est celui qui se prête le mieux à la coopération internationale, vu que sa mission consiste à élargir la sphère des connaissances pour le plus grand bien de l'humanité. Dans ce sens, la science possède un caractère transnational universel. De par leur nature, les sciences de la Terre ont, en plus, une importante dimension régionale, étant donné que leur progrès exige des observations et des relevés dans toutes les parties du globe, puis des communications et des échanges de renseignements. Les besoins de coopération internationale sont évidents.

Les activités scientifiques internationales se déroulent au sein de deux grandes structures. L'une est gouvernementale et relève des Nations Unies, oû la coopération internationale se fait surtout dans le cadre de l'UNESCO. L'autre est non gouvernementale et relève du Conseil international des unions scientifiques (CIUS). Le CIUS comprend 20 unions scientifiques qui traitent chacune d'un domaine bien précis. Trois d'entre elles concernent les sciences de la Terre: l'Union de géodésie et de géophysique internationale (UGGI), créée en 1919, l'Union géographique internationale (UGI), établie en 1922, et l'Union internationale des sciences géologiques (UISG), fondée en 1961.

L'UISG vise, entre autres, à stimuler la recherche fondamentale ou appliquée pour résoudre des problèmes géologiques et à favoriser la coopération interdisciplinaire internationale en géologie et dans les sciences connexes. Les activités scientifiques de l'UISG sont poursuivies par des comités ou commissions internationaux (de la stratigraphie, de la tectonique, etc.) ou par des organisations affiliées et des associations ou sociétés internationales autonomes comme l'UIEQ, l'AIGI, l'ASDI, l'AIGC, la SEG, etc.

Tout comme les autres unions et le CIUS lui-même, l'UISG ne poursuit pas de recherches, mais permet aux milieux scientifiques d'exécuter des travaux qui s'avéreraient impossibles (ou très difficiles) sans une bonne organisation internationale. Elle se contente de fournir une mise de fonds initiale pour les réunions de coordination nécessaires, où ont lieu les échanges d'informations scientifiques, la planification des recherches et la discussion des données et des interprétations.

Depuis quelques années, la géologie prend des dimensions de plus en plus mondiales. Cela est dû au modèle unificateur de la tectonique des plaques, ainsi qu'au nouveau concept qui consiste à voir dans la Terre un ensemble complet aux parties interdépendantes. Au nombre des programmes internationaux de portée planétaire qui ont donné de bons résultats dans le domaine des sciences de la Terre, citons l'Année géophysique internationale (fin des années 50), l'étude du manteau supérieur (années 60) et le Projet géodynamique (années 70). Ces deux derniers programmes ont été poursuivis conjointement par l'UGGI et l'UISG. Leur successeur, le Programme international d'étude de la lithosphère, lancé en 1981, entame maintenant une nouvelle phase dans les années 90 et promet d'aboutir à de grands résultats.

L'UISG encourage également des activités de recherche, de concert avec l'UNESCO. Son point de mire à cet égard est le Programme international de corrélation géologique, lancé en 1972, qui

continue encore à donner de bons résultats. Par ailleurs, l'UISG collabore à certains grands programmes interdisciplinaires comme le Programme international sur la géosphère et la biosphère (changement planétaire) du CIUS et la Décennie internationale de la prévision des catastrophes naturelles, où l'UNESCO joue aussi un rôle important.

Les organisations internationales ne fournissent que la coordination scientifique; les recherches sont effectuées par des chercheurs dans leur propre institution, et c'est pourquoi la participation et l'appui des organisations nationales sont essentiels. Dans de nombreux pays, les commissions géologiques sont les organismes qui font le plus de recherches géologiques, notamment dans le tiers monde, où l'infrastructure universitaire n'est généralement pas très développée. Réciproquement, l'expérience internationale retirée d'une participation utile à des programmes internationaux peut grandement profiter aux commissions géologiques, car les échanges de personnel et d'informations aboutissent à de meilleures interprétations des problèmes régionaux et mondiaux.

I wish to thank the organizers for this opportunity to participate in the sesquicentennial of the Geological Survey of Canada. I'm especially pleased to talk to so many friends from all over the world here in Canada, because Canada, and especially the Geological Survey of Canada, were always very close to the Union. Jim Harrison was the first president of IUGS and Bill Hutchinson was my predecessor as president. But IUGS was also close to Canada because of the extremely important and fruitful voluntary work of so many people from this Survey, such as Ray Price, Chris Findlay, Jim Monger, Mike Berry and many others. A special tribute also goes to Tony Berger and Vera Lafferty, who developed Episodes, the well known IUGS journal. The Canadians had it for ten years, and we must say it was a great help for the Union.

I'm going to talk about international cooperation in the earth sciences. You know that Science is the best field of human activities for international cooperation, since its mission is to create and develop new knowledge which then belongs to mankind. In this sense it has a universal, trans-national character. The earth sciences, in addition, have a built-in, strong regional component, because their development requires observations and measurements in all parts of the world, and that is followed by complete communication and exchange of information.

Besides spontaneous bilateral or multilateral programs between countries, there are two main structures for international scientific activities. One is governmental, and related to the United Nations, where scientific cooperation is mainly dealt with in the United Nations Educational, Scientific and Cultural Organization (UNESCO). Other agencies deal to some extent with earth sciences, like the United Nations Development Programme (UNDP), the UN Disaster Relief Organization (UNDRO), the United Nations Environmental programme (UNEP).

The other structure is non-governmental and it's related to the International Council of Scientific Unions (ICSU). ICSU comprises 20 scientific unions dealing with specific fields, three of which belong to the earth sciences. They are the International Union of Geodesy and Geophysics (IUGG), the International Geographical Union (IGU), and the International Union of Geological Sciences (IUGS). Besides that there are other Unions dealing with different disciplines. ICSU itself deals with inter-disciplinary activities, and two examples of the many scientific committees are SCAR for Antarctic Research and COSPAR for space research. There are also some inter-union committees, such as the Inter-Union Commission on the Lithosphere, that carries out the International Lithosphere Program (ILP).

In the ICSU system, administration is done by a general assembly of all 20 Unions, and all national members, which represent 75 countries. There is a general committee that meets annually and then the Executive Board meets two, three or four times a year depending on necessity. The ICSU structure is based on the scientific unions, which deal with single disciplines and are international in character. The national members are national academies or societies or associations within given countries, that is non-governmental bodies dealing with science. Within ICSU there are also scientific associates, common concerns and services, and interdisciplinary scientific activities to which all the scientific committees and the global programs belong; for example, the International Geosphere Biosphere Program (IGBP), which is the largest.

The Council interacts with many different scientific organizations, especially the ones which are intergovernmental. The main one is UNESCO, but there are many others such as the World Meteorological Organization, the International Atomic Energy Agency, and so on. ICSU deals with many of those intergovernmental agencies and joint ventures are made in the field of Science.

The international conference "An Agenda of Science for Environment and Development into the Twenty First Century" (ASCEND 21) was a recent venture by ICSU in order to facilitate the building up of a scientific program for the Rio '92 conference of the United Nations. ASCEND 21 was held in Vienna last December with 250 scientists, engineers, and social scientists from all over the world. It was a really inter-disciplinary effort and a complete book will be published in May (next month) in time for the Rio '92 conference. I'm sure it will be a fantastic book, a look into the future.

The IUGS is one of the ICSU's 20 scientific unions. It began in 1961 as an outcome of the International Geological Congress. The Congresses started last century, and we are going to have the next one in Japan in August/September this year. I am very proud to say that IUGS is one of the more active of the ICSU unions in promoting international cooperation.

The basic objectives of IUGS are to encourage the study of geoscientific problems, facilitate interdisciplinary cooperation in the geosciences, and support and sponsor the international Geological Congress. IUGS has a council made up of member countries of the Union. We have 96, more than ICSU itself. The Council meets every four years at the occasion of the Geological Congresses. the Union has an Executive Committee that meets annually, and a Bureau that meets more frequently. The Bureau will meet here in Ottawa next Wednesday, taking the opportunity of being here to carry out some of the actions of the Union. The Union has a permanent Secretariat, in Trondheim, Norway. It has advisory boards that give advice to the Executive Committee. The scientific structure consists of commissions, committees, joint programs and affiliated organizations.

The commissions operate in many sub-disciplines of the geosciences - stratigraphy, tectonics, petrology, etc. The Commission on Stratigraphy, for instance, is older than IUGS itself and has about 2000 members worldwide. It provides recommendations on a global scale which are essential to make stratigraphic correlations. The other commissions work in the same way. There are also Advisory Boards for publications, for research developments, and for remote sensing applications to geology, which make recommendations to the Executive Committee. In addition, there are affiliated organizations, about 30 independent societies or associations, which carry out their scientific work in each of their field of interest.

Examples are the International Mineralogical Association (IMA), the International Paleontological Association (IPA), the International Quaternary Association (INQUA), the Commission for the Geological Map of the World (CGMW), and the Geological Society of America (GSA). Some of them are much larger than IUGS itself.

IUGS, similar to its other sister unions and ICSU itself, does not perform research but allows the scientific community to accomplish activities otherwise impossible or very difficult without adequate international organization. It provides only seed money for the necessary coordinating meetings in which exchange of scientific information, planning of research, and discussion of data and interpretations are made.

You have seen some figures from the large geological surveys all over the world, whose budgets are on the order of 100 or more million dollars for their annual operation. For ICSU, the largest part of its income, 43%, amounting to about 1.5 million dollars, comes from membership contributions. The total income of ICSU is a little more than 3 million dollars.

The largest scientific unions, IUPAC, IUBS and IUGS, all had less than 1 million dollars each. The annual budget of IUGS is of the order of $600,000. The budget for the big International Geosphere/Biosphere Program (IGBP), in 1990, was not more than 1.3 million dollars. Sources are the National Academies, some international societies, and some other external sources like UNESCO. In short, the cost of the entire non-governmental system for science is approximately $10 million, which is much less than an annual operation of any one of the large surveys. However, the benefit/cost of those activities is extremely high, because the extremely small seed money given to any coordinating activity (for instance an IGCP project) produces additional research funds with multiplication factors exceeding 1000.

IUGS is a new scientific union. Before it, only IGU and IUGG dealt with international cooperation in the earth sciences. At the beginning of this century, they dealt mainly with acquisition of regional data, exploration of unknown territories, expeditions and so on. In the last three or four decades there has been an evolution into modelling and interpretation of data. I think the main achievement of the geological sciences is the emergence, in the late 1960's, of the unifying concept of plate tectonics which explains the observed dynamics of our planet. Plate tectonics is regarded as an outcome of the Upper Mantle Project, which was started by IUGG in the early 1960's to look at the upper mantle, and its influence on the development of the earth's crust. The recently formed IUGS (IUGS was formed in 1961) was invited by IUGG to be co-partner in that activity, through Jim Harrison, at that time President of IUGS. In its turn, the Upper Mantle Project was also a direct outgrowth of the International Geophysical Year, and that was a venture in '57/58, planned by ICSU. IUGG had a big part in the IGY in order to solve some specific planetary problems of the Earth, through observations in remote and relatively inaccessible regions such as the Arctic or the Antarctic. And from that endeavor, many of the ICSU's scientific committees had their origins, such as SCOR (oceanographic research) and COSPAR (space research), as well as the already mentioned Upper Mantle Project.

The Upper Mantle Project had a successful successor program in the 1970's, the Geodynamics Project (IGP). It was again a partnership between IUGG and IUGS. It looked at the solid earth as a dynamic system, and made numerous tests for the plate tectonics theory, especially within the oceans. An extraordinary amount of high quality data was produced by the IGP, mainly confirming the predictions of the plate tectonic theory.

The Geodynamics Project was followed by the International Lithosphere Project (ILP), whose main emphasis is to understand the origin and evolution of continents. It's more applied in character and it looks also at geological hazards, natural disasters, natural resources and environmental protection. All these international cooperative research programs, the largest ones in the earth sciences, are originated mainly within the ICSU family, especially by IUGG and IUGS.

IUGS also has partners outside the ICSU family, and the best example is the International Geological Correlation Program, whose co-sponsor is UNESCO. I will not speak on IGCP, because Dr. Naldrett will do so in detail. Other programmes with UNESCO are the Deposit Modelling Program (DMP), and GARS. The DMP deals with workshops and field work on selected ore deposits mainly in developing countries. Interaction of local geologists with first class economic geologists is very fruitful. GARS (Geological Application of Remote Sensing) is directed towards technology transfer, namely Remote Sensing technology transfer to developing countries. As an example, I shall mention last year's effort in Columbia to identify landslide-prone areas in the Andes through the examination of satellite imagery.

The Circum-Atlantic Project is a large program to develop maps, data banks and so on in the region of the Atlantic and the countries around it. IDNDR, the International Decade of Natural Disasters Reduction, is a world-wide operation, and many of the unions of ICSU are part of it. It was started by a resolution of the U.N. General Assembly, declaring the 90's as a decade for natural disaster reduction. The major effort will be by governments, in order to make prediction and prevention of disasters rather than relief and reparation. Then we have the IGBP, the International Geosphere-Biosphere Program, which is the main program of ICSU, and IUGS, as well as many other sister unions, is participating in this. It must be stressed here that global change activities within ICSU include IGBP as one program, as part of the main research system. WCRP (World Climate Research Program), SCOPE (Scientific Committee Related to Environment) and many scientific unions and scientific committees also participate with their own programs on global change. However very big, IGBP is only one program on global change.

Since the international organizations provide only scientific coordination, research is carried out by scientists in their own institutions, and thus participation and support by national organizations are essential. In many countries the geological surveys are the strongest organizations in the earth sciences, and that is so especially in the Third World, where the academic institutions are usually not very well developed. Hence, the geological surveys play a major role in international cooperation. The input from geological surveys into IUGS activities has always been very strong. We have a permanent Secretariat which is located at the Geological Survey of Norway. The Chairman of our Advisory Board for Research Development is Roye Rutland, from the Bureau of Mineral Resources of Australia. Among the officers of the Executive Committee of the Union, we have Robin Brett from the USGS, Michael Schmidt-Thomé, from the German BGR, Mohammed Bensaid, from the Moroccan Survey, and Godfried Kesse, from the Geological Survey of Ghana.

IUGS also has many members from geological surveys in programs such as Deposit Modelling, the first chairman of which was Chris Findlay. A special subcommission of IUGS is on global data management and information systems, and has representation of the major geological surveys throughout the world. The aim of it is to standardize and exchange geological and geophysical data.

I wish to stress the symbiotic relationship between the Union and the surveys. Necessarily, there is a great involvement of the geological surveys with IUGS, and IUGS will have insuperable difficulties without support from the surveys. Reciprocally the surveys also benefit from the interaction and the effective participation in international programs, because of the exchange of personnel and exchange of information. Their geologists in this way receive relevant expertise, to be applied later in the interpretation of the regional data and global programs.

I hope that these few examples I have given to you are sufficient to stress the importance of international cooperation for scientific development in geology. Moreover, they show the symbiotic character of the participation of governmental and non-governmental scientific bodies. Everybody gains if these activities are carried out properly, for the development of science and benefit of society.

The International Geological Correlation Programme: Past, Present and Future

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Abstract

The IGCP, along with MAB, IHP and IOP, constitutes one of the four main scientific programs within Unesco, and is the largest program within the Division of Earth Sciences. It was formed in 1972 as a result of a joint initiative of Unesco and the IUGS. Money (currently about US $280,000 per year), 60% provided by Unesco and 40% by the USA and UK through USGS, is administered by a Unesco-based secretariat and acts as a seed for between 45 and 55 projects. The average of US $5,500 per project does no more than fund attendance at a conference of 2-3 people per project per year, but because of the enthusiasm within projects, this is sufficient to harness and focus on international collaborative research an average of close to 1,000 times more money than the IGCP seed.

New projects are proposed by the researchers themselves, and the proposals are reviewed yearly, together with the progress of on-going projects, by a scientific committee chosen jointly by Unesco and IUGS. Overall direction of IGCP falls to the board which also meets yearly. The strengths of the program lie in the grass-roots origins of its projects (which means that all of those involved are keenly interested), in the limited life-span of the projects (generally 5 years, which means that they don't become stale), and in its ability to add a legitimacy to research projects (which enables them to attract a wide level of well-funded international support). The legitimacy comes from the very high scientific stature of IGCP: good science and wide international support are the prime criteria on which new projects are selected and on-going projects are supported. A perceived drawback is that the programme does not lend itself to being targeted at priorities; the IGCP is reactive rather than proactive.

Looking to the future, we are faced with different problems and different roles that geologists must tackle if they wish to stay employed. It is my view that Project 259, which is concerned with International Geochemical Mapping, is a signpost for things to come. This is a major collaborative effort between governmental institutions in over 40 countries. It will not finish its task within the allotted time frame, it will only finish finding out how to accomplish its task. However IGCP assisted in its birth and Geochemical Mapping now has the momentum to continue on its own. I see IGCP playing an increasing role as a proving ground for some of the international initiatives that are needed to help us cope with our changing world and for which the resources of individual scientists scattered across the globe are insufficient. I believe that IGCP, with its outstanding ability to bring researchers together from all parts of the world, will help in focusing geoscientists of all kinds, from isotope geochemists to paleontologists, from chemical thermodynamicists to structural geologists, on the problems associated with survival on a crowded planet.

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Résumé

Le PICG est l'un des quatre grands programmes scientifiques de l'UNESCO, les trois autres étant l'Homme et la biosphère, le Programme hydrologique international et la COI. C'est, en outre, le plus grand programme de la Division des sciences de la Terre, qui a été lancé en 1972, à la suite d'une initiative conjointe d'UNESCO et de l'UISG. Son budget, qui s'élève actuellement à quelque 280 000 dollars américains par an et dont 60 p. 100 provient d'UNESCO et 40 p. 100 des États-Unis et du Royaume-Uni, par l'entremise de l'USGS, est administré par un secrétariat basé à UNESCO et sert à assurer le financement de démarrage de quelque 45 à 55 projets. La somme de 5 500 $ en moyenne par projet permet, au plus, à deux ou trois personnes par projet par an d'assister à une conférence, mais, en raison de l'enthousiasme que soulèvent les projets, cela est suffisant pour valoir aux recherches coopératives internationales des investissements correspondant à près de mille fois la somme fournie par le PICG.

De nouveaux projets sont proposés par les chercheurs eux-m,mes, et un comité de scientifiques choisis conjointement par UNESCO et l'UISG examine chaque année les projets proposés, ainsi que les progrès des projets en cours. La direction générale du PICG est assurée par son conseil d'administration, qui, lui aussi, se réunit une fois par an. Les atouts du programme sont le fait que les projets sont proposés par les chercheurs (ce qui veut dire que tous ceux qui y participent s'y intéressent vivement), la durée limitée des projets (cinq ans en général, ce qui veut dire que les projets ne perdent pas leur élan), et le fait qu'il donne aux projets de recherche le sceau de la légitimité (ce qui leur permet d'attirer plus facilement l'appui et le financement à l'échelle internationale). Cette légitimité découle du très grand prestige scientifique du PICG : la validité scientifique et l'ampleur de l'appui international sont les principaux critères utilisés pour choisir de nouveaux projets et appuyer des projets en cours. L'une des lacunes du programme est qu'il peut difficilement s'orienter vers des priorités : il y réagit au lieu de les prévoir.

Si l'on se tourne vers l'avenir, on se rend compte que les géologues doivent aborder divers problèmes et assumer divers rôles s'ils veulent continuer d'avoir un emploi. À mon avis, le projet 259, qui porte sur la cartographie géochimique internationale, est une indication de ce que l'avenir nous réserve. Il s'agit d'un grand projet de collaboration entre des institutions publiques de plus de 40 pays. La tâche ne sera pas terminée dans les délais impartis. On aura seulement eu le temps de découvrir comment la mener à bien. Toutefois, le PICG l'a aidé à démarrer, et le projet a maintenant pris un élan suffisant pour continuer tout seul sur sa lancée. Je pense que le PICG servira de plus en plus de banc d'essai à certaines initiatives internationales qu'il faut lancer pour nous aider à nous adapter à l'évolution de notre monde, quand les ressources de chercheurs individuels éparpillés sur tout le globe ne suffisent pas. Vu qu'il excelle à réunir des chercheurs du monde entier, je suis convaincu que le PICG aidera les spécialistes des sciences de la terre, depuis les spécialistes de la géochimie isotopique jusqu'aux spécialistes de la géologie structurale, en passant par les paléontologues et les thermodynamiciens chimistes, à se concentrer sur les problèmes de la survie sur une planète surpeuplée.

Before starting, I'd like to say how honoured I am to talk on IGCP at this 150th anniversary party. I've never worked for the GSC, but to any Canadian scientist, the contributions of GSC personnel are so great, their knowledge so broad, and their advice so wise that very soon, employee or not, the Survey gets into your blood and is a part of your environment. You can't do without it. Bon Anniversaire.

EARLY HISTORY

The International Geological Correlation Programme was born here in Canada 20 years ago when IUGS accepted it at their executive meeting during the Montreal International Geological Congress. It was conceived and has continued as a joint IUGS-Unesco collaboration. Over the past 20 years it has developed into one of the four main scientific programmes of Unesco, along with Man and the Biosphere or MAB, the International Hydrologic Programme or IHP, and the Intergovernmental Oceanographic Commission or IOC.

IGCP falls within the Division of Earth Sciences at Unesco. It is overseen by a Board, and new and on-going projects are reviewed by a Scientific Committee. The first meetings of the Board and Scientific Committee were held in May 1973. The members of these bodies are chosen by Unesco and IUGS jointly from candidates proposed by participating countries. Sir Kingsley

Dunham of the United Kingdom was the first chairman of the board and Digby McLaren of Canada was one of its members; Digby subsequently became chairman in 1977. Canadians who have served on the Scientific Committee include Ted Irving, W.W. Hutchison, Bosco Loncarevic and now Ray Price who is the current chairman. Hitherto, each body has met yearly, although financial pressures may cause this to change in future.

The programme is administered by a professional geologist attached to Unesco who acts as secretary and runs a small secretariat. Felix Ronner of Austria was the first secretary, and was succeeded in 1975 by Eckardt von Braun of West Germany; he was succeeded in turn in 1986 by Endre Dudich of Hungary. This year will be Endre's last and I would like to take this opportunity of stating how much the international geological community is indebted to him for all his hard work.

MODE OF OPERATION

Most countries co-ordinate their activities in IGCP through national committees which numbered 91 in 1991. About 180 projects have been part of the programme since its inception in 1972-73. Projects are proposed by individual scientists, who see a need for international cooperation in a particular area of science, solicit support from their colleagues and national committees and then approach the secretariat with a scientifically sound, internationally supported project proposal. These are reviewed by the Scientific Committee, who advise the Board on whether to accept them or not. The Board then makes the decision with a recommendation as to the general level of funding. Projects have lasted from 4 to 10 years, although 5 years is the maximum time awarded any project at present.

Funds for IGCP come from two sources, Unesco and IUGS. The IUGS in fact merely acts as a conduit for contributions from the USA and UK who, although not members of Unesco, participate very actively in all aspects of IGCP. For the biennium 1992-93 IGCP, along with all other activities of Unesco, was assessed a 21% redistribution of Unesco contributions, which is UNESCOese for a cut of this proportion. In order to cope with this cut, heavy pruning was again undertaken at this year's board meeting. The pruning was most ruthless in the recommendations that were given to IUGS and Unesco with regard to the membership of the Board and Scientific Committee; it was suggested that they be greatly reduced in number and meet for less time in future years. The result has been that despite the cut, funding has remained approximately constant from 1991 to 1992 at an average of about $6000 per project.

What can be done with this $6000? What is done forms the heart of the success of IGCP. This small amount of money provides a seed for holding 1, 2 or 3 meetings per year per project. Normally it is used to pay partial support of a few key speakers; these act as magnets for 50 to 100 other participants at the meeting who find their own funds to attend. In this alone one sees a multiplication of 25 to 50 times the initial Unesco seed money. However this is just the start.

Participants in IGCP projects compete for funds, either from peer-adjudicated funding organizations or governmental institutions. These funds are then available to help achieve the research objectives of the IGCP project in question. The multiplication factor to the initial $6000 seed in terms of research achieved is in most cases much more than 200 times. And this is money that would have been spent in any case, except that through IGCP it is being directed at global collaborative projects.

STRENGTHS AND SUCCESSES

What attracts the earth scientist to IGCP? Geologic structures are not, for the most part, respecters of international boundaries, even though boundaries occasionally respect geologic structures. Geologists need to carry their studies across these boundaries and IGCP provides the route through the barriers that mark them. This comes about because of the credibility of the names of its two sponsors, Unesco and IUGS. This credibility persuades governments to allow, even encourage their nationals to participate in projects.

Because of its international character, and because of the influence of Unesco, IGCP provides links between more and less developed countries, and results in the establishment of information networks. Some projects have been specifically designed to combine the sophisticated equipment and technical expertise of a developed country with the field expertise and local knowledge of geologists in a less developed country.

The success of IGCP within the geoscience community is illustrated in many ways, and was particularly evident at the last International Geological Congress in Washington at which nearly half of the sessions had some connection with IGCP. This success comes from the strengths of the programme; these lie in the grass-roots origins of its projects (which means that all of those involved are keenly interested), in the limited life-span of the projects (which means that they don't become stale), and in IGCP's ability to add a legitimacy to research projects (which enables them to attract wide-spread, well-funded international support). The legitimacy comes from the very high scientific stature of IGCP; good science and wide international support are the prime criteria on which new projects are selected and on-going projects are supported. Many of the more successful projects have been reborn as successor projects with somewhat different objectives, normally under different leadership. In other cases commissions or subcommissions of international organizations have arisen from the ashes of IGCP projects.

PROBLEMS AND WEAKNESSES

Gratifying as this success is, it has brought its problems. Funds available to the programme have not increased; as I have already mentioned this year has seen a 21% decrease. Last year we had a record 27 submitted proposals. By being very tough, refusing all extensions that had not been granted in previous years and accepting only 10, we were able to hold the increase to one, which nevertheless meant that there were a record of 55 funded proposals in 1991. I have also already referred to the pruning that we had to undertake this year and noted that we have been able to hold the average funding per project approximately constant. This has been done at a cost - the cost of refusing extensions to several projects that in a better financial climate should have received them, and in turning down several worthy new proposals. The result is that we now have 48 funded projects.

The failure of Unesco funding to grow with the programme, indeed even to remain constant, means that US and UK funding now constitutes 45% of that supporting projects. If this trend continues we will soon have to speak of IGCP as a US-UK programme assisted by Unesco. The danger is that either the US or the UK funding could disappear overnight at the whim of a committee or an influential individual seeking to divert funds elsewhere or look for economies in a budget. If this happened, IGCP would be unworkable.

So far I've described the history of IGCP, its structure and the way it operates, I've spoken of its successes and the factors behind these, and have voiced some concern over future funding.

Does it have any weaknesses? A perceived weakness arises directly out of one of the main reasons for its strength. Because individual groups of scientists propose projects, because projects rise from the grass roots upwards, the programme does not lend itself to being targeted at priorities; IGCP is reactive rather than proactive.

I don't need to tell most of you in this audience composed of directors and other leaders of national geological surveys that we live in a different world from that of 20 years ago. In most of the developed world the mining and petroleum industries are barely holding their own or are declining.

All of us here know that a geologic map is not a statement of fact but an interpretation of facts in the light of prevailing ideas. As ideas change, maps change, and so the ideas change even further. Unfortunately, there is a view in government that once an area has been mapped and an opinion expressed, the work is complete. Somehow we have not got our message across that geological research and the recommendations of geologists evolve over time just as much as medical research and the recommendations of doctors. The result is that it is difficult to get non-geologists to see the importance of projects involving remapping or the reworking of maps, such as those concerned with correlation around the margin of Tethys, study of circum-Atlantic or Pacific terranes, or ultrametamorphism and its significance, vital as they may be to us and the development of our science.

What I am stressing is that there is no doubt that IGCP suffers from the almost universal inability of geologists to sell themselves. I was at the Unesco General Conference last October in my capacity as Chairman of the IGCP Board. All scientific issues are considered at the meeting of Commission III. The order of business is for the chairmen of programmes to make their reports and then each country in turn to comment on progress within Science at Unesco as a whole in a series of 5-10 minute "interventions" which have been prepared well ahead of time. A total of 95 countries made interventions. Of these, 78 commented on the good work done by IHP and IOC, 75 on the good work done by MAB and only 32 on the good work done by IGCP. The countries congratulating IGCP were almost exclusively those from the third world; essentially no western European countries included a mention of IGCP in their interventions. These comments are counted, analysed and used as ammunition by Unesco staff; while IGCP received no bad comments, the conspicuously fewer commendations that we received in comparison with the other programmes doesn't provide a lot of ammunition for our supporters.

Why was this? IOC have never been shy to emphasize their importance in monitoring ocean currents and the relationship that these have to fish stocks and the weather, and also their role in monitoring ocean pollution; IHP are always quick to stress their role in building an inventory of the earth's fresh water stocks, the advice that they can provide on the trans-border transport of water, and the monitoring of the pollution of subsurface water; MAB involve the media more than any of the other programmes in publicizing such programmes as their biosphere reserves and their other contributions to understanding our environment. IGCP projects are proposed by those who tend to think within the time frame of geological processes rather than the "real time" of a human life-span; thus the projects give the impression of lacking relevance. The Earth Science Division Programme that received the most attention at the Unesco General Conference was that allied with the UN-sponsored International Decade for Natural Disaster Reduction.

You, ladies and gentlemen, being among the most influential geologists in your countries, can do your bit to help IGCP. You can find out who prepares your country's intervention to Commission III; generally it is your National Commission for Unesco if you have one, or if not, someone in your Department of Foreign

Affairs; you can explain to them how important IGCP is, and ask that they make mention of it in their intervention - you can even write a few words for the intervention; these should not amount to more than one sentence.

IDEAS FOR THE FUTURE

Even if we do a better job of selling our science, the fact remains that IGCP needs to evolve. How should it evolve and how can the evolution be brought about? I don't believe that the basic structure should change, nor should the way in which projects are proposed or evaluated; these are too fundamental to the concept and to the success of IGCP.

It is my view that project No 259, International Geochemical Mapping, is a signpost for things to come. This was proposed by Arthur Darnley of the Geological Survey of Canada. It suggested that the world should be covered by geochemical maps, showing a variety of elements and ratios of elements. Many of these maps are available for restricted parts of the world, but they have been made using different analytical techniques and different standards. What was needed was to decide how to combine maps, what elements to concentrate on, how to standardize results from a wide spectrum of laboratories, and how to fill in the gaps.

This was a vast undertaking, which received an initial rocky reception from the Scientific Committee and Board, because it seemed to lack a readily achievable goal; it was far too vast and diffuse to be accomplishable within 5 years. These views expressed at the onset have proved to be correct, but within its 5-year life-span IGCP Project 259 has been able to develop extraordinarily wide international support. It has been demonstrated that major geochemical features can be delineated in China with soil samples collected 1 per 1400 km^2, in Labrador with lake sediment sampling of 1 per 625 km^2, and in Finland with till sampling of 1 per 300 km^2. The overwhelming usefulness of soil sampling, augmented by stream and lake sediment samples, has been shown in comparison with overbank sampling for delineating the broad-scale features that are the focus of the project. Technical committees have been established covering the topics of field, analytical, data management, radiometric and global reconnaissance problems, together with regional committees for North America, Fennoscandia, the EC, eastern Europe, the ex-Soviet Union, China, India, southern Africa and Australia. Project 259 will conclude with an enormous momentum and with the involvement of 80 national institutions, largely the surveys that you, this audience, represent.

Now we look to this child of IGCP to fulfil as an adult the promise that it showed during its childhood with us. Indications that it will do this include the establishment in 1990 of a Working Group on Global Geochemical Mapping under the International Association of Geochemistry and Cosmochemistry, and the announced intention of proposing a successor IGCP project on "International Geochemical Baselines".

I believe that similar programmes of international collaboration, responsive to the needs of our changing world, can seek a protected infancy of 5 years as an IGCP project. If you think similarly, and contemplate developing a proposal, remember that it must demonstrate wide international support; it must fulfil the scientific requirements of IGCP - data gathering alone is unlikely to be sufficient; and it must be capable of achieving some concrete objectives during a 5 year life-span, even though these may be preliminary to the establishment of a much bigger programme.

In conclusion, in the future I believe that IGCP can play an increasing role as a proving ground for some of the international initiatives that are needed to help us cope with our changing world and for which the resources of individual scientists scattered across the globe are insufficient. IGCP, with its outstanding ability to bring researchers together from all parts of the world, can help in focusing geoscientists of all kinds, from isotope geochemists to paleontologists, from chemical thermodynamicists to structural geologists, on the problems associated with survival on a crowded planet. Whether it does this or not is up to the earth science community; it is up to us to submit proposals with these objectives. Those of you here who play prominent roles in your national surveys have a special responsibility to see that this comes about.

Theme V Discussion

Unidentified Speaker: I think that COGEOENVIRONMENT might be quite an important issue .

U.G. Cordani: Yes. It is only two years old but it is doing a very good job. The chairman is a member of the Geological Survey of Norway, Frederick Wolff.

D.L. Peck: The sponsors of this congress have suggested that it might be desirable to have a committee or organization of geological surveys. The IUGS grew out of the International Geological Congress which was a congress, at least in part, of geological surveys. What is your reaction to the proposal, and is there any logical relationship between a committee of geological surveys and the International Union of Geological Sciences?

U.G. Cordani: Having separate efforts in the same direction, is a very good idea. I favour having a commission on geological surveys which represents the geological part of governments all over the world, and may have a direct impact on policymakers. Besides global change and environment, there is also resource management; we may look into prices of ores and other things important for the geological community. The Scientific Union is very close to the geological community, and many members are from the geological service. So we look at the geological and technical aspects and at the profession in general. IUGS represents geologists all over the world. The international congress is our major gathering and is a good opportunity to make links. Whether this commission is coming to life depends on what you decide here. IUGS is looking forward to having a partner in the difficult job of making geology visible. Many speakers noted that we have difficulty communicating with politicians and policymakers. Even our colleagues, economists and lawyers don't have enough geological background to understand us. However, we are also guilty because we live in isolation. We have to modify our attitude to communicate to make geology more visible. We can undertake separate, parallel, or convergent actions, to do that. The geological surveys are a major part of the geological community.

Unidentified Speaker: Cooperation between surveys, academia, etc. and museums is significant. I suspect many people here got their early interest in the Earth Sciences by poring over cases of exhibits in museums, even when museums did not have the exhibitions we're used to now.

REGIONAL PERSPECTIVES

Geological Work in China and its International Cooperation

Zhu Xun[1]

Zhu, Xun, Geological Work in China and its International Cooperation; in National Geological Surveys in the 21st Century, Bouchard, D.S. et al. (compilers), Geological Survey of Canada, Bulletin 446, p.139-142, 1993

Abstract

The broad territory of China boasts rich mineral resources. After 40 years of geological work since the foundation of New China, 163 varieties of usable minerals have been found, for 149 of which reserves have been proven.

The Ministry of Geology and Mineral Resources of China is an agency directly under the State Council responsible for the unified administration of national geological work. It has a team of 400,000 people, including nearly 90,000 geological professionals, mainly conducting basic, comprehensive, frontier and public geological work. Its strong research program has 5 academies and their tens of institutes carrying out basic research and technological and methodological research in different disciplines. Bureaus of geology and mineral resources located in 30 provinces, municipalities and autonomous regions of the country and their subordinate geological teams undertake regional geological surveys, geological mapping of all kinds of scales as well as prospecting and exploration of various kinds of minerals. There is also a special geological team in different mining departments of China undertaking the detailed exploration for minerals of their respective responsibility needed before development can take place.

The mineral resources proved to date are far from enough to meet the need of national economic construction. The work ahead is tough. The priorities for the future should be to strengthen the research in mineral resources in order to solve some key issues in mineral prospecting, like establishing better deposit models, effective theory and comprehensive methods for mineral exploration. The priority commodities should be energy, precious metals, copper and minerals for agricultural use.

International cooperation is very important to the development of geosciences. Our ministry has established contacts with 116 countries or regions in the world so far, signed 38 bilateral cooperative agreements with 22 countries, participated in 28 international academic organizations and kept constant contacts with 12 organizations in the United Nations.

The World Organization of Geological Surveys proposed could be a good forum for the international geoscientific community to exchange discussion about the common challenges we face, jointly seek solutions, and share the results and experience of geoscientific research which will be beneficial to the development of international geoscience and the common advance of mankind.

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Résumé

Le vaste territoire de la Chine est riche en ressources minérales. Après 40 ans de travaux géologiques depuis la fondation de la nouvelle Chine, on y a trouvé 163 variétés de minéraux utilisables et des réserves prouvées pour 149 d'entre eux.

Le ministère de la Géologie et des Ressources minérales de la Chine est un organisme qui relève directement du Conseil d'État responsable de l'administration centrale des travaux géologiques nationaux. Il a un effectif de 400 000 personnes, dont près de 90 000 spécialistes de la géologie, dont la tâche consiste surtout à poursuivre des travaux de géologie de base, approfondis, innovateurs et publics. Son vigoureux programme de recherche se poursuit dans cinq académies, où des dizaines d'instituts effectuent des recherches fondamentales, ainsi que des recherches technologiques et méthodologiques dans différentes disciplines. Les bureaux de géologie et des ressources minérales situés dans 30 provinces, municipalités et régions autonomes du pays, ainsi que leurs équipes géologiques, effectuent des levés géologiques régionaux, la cartographie géologique à des échelles diverses, ainsi que la prospection de divers types de minéraux. Par ailleurs, les différents services des mines ont une équipe géologique spéciale, qui procède à la prospection détaillée des minéraux relevant de sa compétence, avant toute mise en valeur.

Les ressources minérales prouvées jusqu'à présent sont loin de suffire aux besoins de développement économique national. La tâche qui nous attend est considérable. Nos priorités pour l'avenir doivent consister à renforcer la recherche sur les ressources minérales afin de résoudre certains problèmes cruciaux de la prospection, par exemple en établissant de meilleurs modèles des gisements, en concevant des théories efficaces et en mettant au point des méthodes intégrées de prospection. Il faudrait se concentrer sur les ressources énergétiques, les métaux précieux, le cuivre et les minéraux utilisés en agriculture.

La coopération internationale joue un rôle très important dans l'avancement des sciences de la terre. Jusqu'à présent, notre ministère a établi des liens avec 116 pays ou régions, a signé 38 accords de coopération bilatérale avec 22 pays, participe à 28 organisations scientifiques internationales et reste en communication constante avec 12 organisations des Nations Unies.

L'organisation mondiale de commissions géologiques qui est proposée serait une excellente tribune, car elle permettrait aux géoscientifiques du monde entier d'échanger des idées à propos des problèmes communs auxquels ils doivent faire face, de chercher ensemble des solutions et de partager le résultat de leurs recherches, ce qui ne peut que profiter à l'avancement des sciences de la terre à l'échelle internationale, et se traduire en progrès pour l'humanité.

I would like to congratulate the GSC on its 150th Anniversary for its significant contribution to the earth sciences. The Ministry of Geology and Mineral Resources of China and the GSC have been cooperating successfully. I am grateful to be granted the honour of delivering a talk about the geological work in China and its international cooperation on behalf the Ministry of Geology and Mineral Resources of China.

China boasts rich mineral resources within its vast territory. Since the founding of New China in 1949, systematic geological surveying and exploration have been carried out. Over 200,000 mineral deposits have been discovered, 163 species of useful minerals have been found, and reserves of 149 of these have been established. Out of these, reserves of 60 species are substantial. Over 130 species of mineral deposits are mined and utilized in China; and 95% of the energy and 80% of the raw materials for industry are derived from mineral resources. The mining industry has become one of the important bases of the national economy. There are 8,800 state-run mining enterprises, 125,000 township mining collectives, and 115,000 individually-owned mining pits in China. In addition to 3 billion t of building materials, 2.1 billion t of ore are produced annually. The ore has a value of about 122 billion yuan, making China third among the world's solid-state mineral producers. The annual gross production of coal amounts to 1.08 billion t, ranking first, globally; oil and gas, 139 million t, ranking fifth; iron ores and nonferrous metals, ranking fourth; phosphate rocks, ranking third; and cement, ranking first. Generally speaking, the mineral commodities have met the needs for agriculture, the energy industry, the iron and steel industry, the nonferrous metals industry, the chemical industry, and the building material industry. Quite a few mineral commodities are available for export.

The Ministry of Geology and Mineral Resources is a functional department under the State Council responsible for the unified administration of geological work and mineral resources throughout the country. About 1.1 million geoscientists, staff and workers are involved in the geological work in the whole country, out of which 400,000, including 90,000 professionals, belong to the Ministry of Geology and Mineral Resources. They conduct basic, comprehensive and pioneering research. The staff and workers are distributed throughout 30 provincial bureaus, 6 regional bureaus of petroleum geology, the Chinese Academy of Geological Sciences and four other research institutes. Besides the academy and institutes mentioned above, 120 organizations for geoscientific research, 105 geological departments, colleges and universities, and 900 geological parties are distributed in various places throughout China.

We undertake multidisciplinary investigations and conduct geological research onshore, offshore, and conduct surveys using airborne techniques.

Geological work in China, 60-80% of which is focused on exploration of mineral and energy resources, can be divided into three categories: basic geology, economic geology and comprehensive environmental geology. Basic geology has been conducted by geoscientists from the Chinese Academy of Geological Sciences, parties of regional geological surveys, and geophysical or geochemical teams of the provincial bureaus, geological departments, and colleges and universities. A geological survey of 1:1 million scale has covered the whole continent of China, while that of 1:200,000 scale covers two thirds of the country, another of 1:50,000 scale covers more than 700,000 km^2. Other geochemical surveys have been completed on small to medium scales. Deep geological investigation is carried on in several selected areas. Since the 70's, especially in the last decade, Chinese geologists have attached importance to research on oceanic and Antarctic geology and planetary geology.

Theoretical studies have been conducted on oil generation in terrestrial facies, geotectonics, models of metallogeny for iron related to porphyrite, tungsten and tin related to porphyry, gold related to alterated rocks, and the metallogenetic theory developed for Nanling and the Yanshanian tectonic belt.

As early as the 50's, comprehensive environmental geological work, (i.e. hydrogeology, engineering geology and ecological geology) started in the whole country and focus was placed on the regional hydrogeological and engineering geological surveys. In the late 50's, large-scale balance testing sites of groundwater and monitoring systems of groundwater pollution were set up. In the 60's, research and control of ground subsidence was begun in Shanghai and Tianjin. In the 70's, a project dealing with environmental research concerning groundwater cycling within plain areas had been launched. By the end of the 80's, a multi-functional monitoring system of groundwater, including 18,000 observatory sites had been completed, and the hydrogeological survey and mapping on the scale of 1:200,000 covered more than 8 million km^2 on the Chinese continent. The exploration and exploitation of water sources have been successful to a certain extent. Research on engineering geology has provided information to construction projects, such as ports, railways, tunnels and irrigation installations, and laid the foundation for planning urban construction and some key projects. Recently, exploration of groundwater, mineral fertilizer, animal feed and agricultural land-planning have been specially emphasized.

Chinese geoscientists apply the geochemical theory founded by Prof. Li Siguang to monitor earthquake hazards. Also, the observation and control of geological disasters, such as ground sudsidence, geofracture, land slides and debris-flow, are underway all over China.

In addition to the geological parties under the Ministry of Geology and Mineral Resources (MGMR), there are nearly the same number of geological teams under the Ministry of Energy, the Ministry of Metallurgical Industry, China National Nonferrous Metals Industry Corporation, the State Bureau of Building Materials, the Ministry of Chemical Industry and the Ministry of Light Industry.

In spite of the great achievements acquired through extensive geological work in the past forty years, the certified mineral deposits still can not meet the ever-growing demands of national economic construction. So, we Chinese geoscientists are facing serious challenges.

Although gross mineral resources are abundant, the average per capita amount is less than half of that in the world. China is poor in resources of chromite, diamond, and sylvanite. Iron and copper resources are relatively scarce. A large proportion of manganese reserves are composed of lean ores which are difficult to enrich economically. Moreover, groundwater distributes unevenly in China; lack of water badly affects industrial and agricultural production and the normal life of residents of northern China. Geological hazards frequently cause loss of lives and property. The increasing depth of mineral resources and consequent difficulties of mineral exploration will undoubtedly become more and more challenging subjects for geological theories and techniques.

The Chinese government has put forward a five-year plan and ten-year programme for national economic development. Coincidentally the Ministry of Geology and Mineral Resources has worked out a few "ten-year programmes" (i.e. mineral exploration, hazard reduction, and geological promotion depending upon science and technology), and decided the major tasks for the future as well.

Using information on geochemistry, geophysics and remote-sensing, combined with the application of new metallogenetic theory, we are reinforcing the search for copper, noble metals, petroleum and other urgently-needed minerals. We are trying our best to make a breakthrough discovery of new types of large scale mineral deposits. It has been suggested that detailed research into mining geology should be intensified in order to improve the recovery ratio and extend the service years of the mines. Progress in ore-dressing and processing technology should also be made in order that lean ores and ores mined from mineral deposits with complex composition can be fully utilized.

Research into environmental geology is significant in understanding the interaction between human beings and the natural environment. Quite a few key projects related to the protection of the geological environment and reduction of geological hazards have been carried out.

All inhabitants of the earth share the same globe. The geoscientific study of the earth can, therefore, be well developed only through international cooperation and exchange. We are placing more emphasis on international cooperation. The Ministry of Geology and Mineral Resources of China has made striking progress in international exchange because the policy of reform and opening to the outside world has been implemented. As a result, up to now, MGMR of China is conducting exchange programmes with 115 countries or regions, and has signed 88 bilateral cooperative documents with 30 countries, kept constant contact with 12 UN organizations and joined 28 international bodies of geoscience. Various styles of cooperation and exchange programmes have been adopted. For instance, many Chinese geoscientists have been sent abroad to study various new geoscience, technology and management concepts, and in return we have received thousands of foreign geologists to share our experiences and ideas in China. Some cooperative projects last for two to three years and have made strides. Many international conferences and training courses, workshops, and symposia, were held in China to exchange results of geoscientific research, discuss special topics of different branches of geoscience in depth, and train young geoscientists. Taking into account the development of international economic cooperation in connection with geoscience, Chinese geoscientists have undertaken varied tasks of regional geological surveying and mapping, exploration and reconnaissance or economic evaluation of mineral deposits, chemical analysis, and testing experiments for many other countries. Now we are preparing to host the 30th International Geological Congress in Beijing in 1996. Fellow geoscientists abroad are welcome to cooperate with us within a wider scope, in order to promote the development of geoscience and contribute more to the social progress of mankind.

We approve of the proposal of organizing the World Committee of Geological Surveys, raised by the colleagues from Canada and other countries, and ascertain to undertake a committed obligation as a sponsor nation. Needless to say, this committee will surely become an international forum of geoscientific circles and create opportunities for them to discuss the common problems confronted by various countries, seek ways to resolve them and share achievements and experiences in order to accelerate the development of the geosciences.

The demand for mineral resources is increasing because of the ever-growing population and economy on one hand, and the fact that consumed mineral resources can not be regenerated on the other hand. Since it is more and more difficult to search for new mineral deposits, the gap will become wider and wider between the supply and consumption of mineral resources. Based on this situation, we as geologists should persuade people to cherish the mineral resources for the sake of our future generations.

We would like to propose that the UN initiate a "World Day of Mineral Resources Protection". On that day every year, publicity for resource protection should be launched all over the world in order that people will be aware the importance of our valuable mineral resources.

Evolution of Geological Surveys in Africa

C.A. Kogbe[1]

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Abstract

The history of geological surveys in Africa can be conveniently subdivided into two periods: the colonial period and the post colonial period.

African geological surveys, like their counterpart in other parts of the world, were established to execute geological mapping of different territories.

They were charged with the investigation and evaluation of mineral resources. Geological reports and maps were produced to record the results of field and laboratory investigations. This major objective still constitutes the "raison d'être" of most of the surveys in the continent.

During the colonial period, the geological surveys were adequately equipped for carrying out geological field mapping and mineral exploration. Field conditions were difficult but facilities were provided to guarantee the success of field expeditions. The rocks, minerals and fossils collected during field campaigns were later analyzed at the Survey Headquarters in Africa or they were dispatched to "back-up" laboratories in England, France, Belgium, or Portugal for further study by experts. Remarkable results were attained by the surveys in the first two to three decades of their existence. Over 50% of the continent was mapped and the geological framework of the continent was defined. Many mineral deposits were found and later exploited by European mining companies. The geological surveys in Africa were of primary economic significance to the colonial masters and funding the Surveys adequately was a priority. The results definitely justified the investment.

With political independence, the surveys did not change their role but the level of funding declined. Old equipment was not replaced. Field vehicles were either inadequate or non existent. The surveys unfortunately became bureaucratic institutions and this sad situation is still prevalent in most African countries with the very rare exception of a few countries like South Africa, Botswana, and Egypt.

To continue to exist as national institutions, African geological surveys must change their outlook. They must evolve from the basic task of producing maps and become centres for mineral resources development. The mineral resources outlook must be broad-based and should include minerals, water and fossil fuels.

To achieve this new role, regional cooperation is necessary to minimize the financial out-lay and maximise the benefits. Well-equipped laboratories with up-to-date analytical equipment, computerised database and access to remote sensing facilities have become imperative. Geology has made tremendous progress in the last few decades. Africa cannot afford to be left behind.

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Résumé

Pour simplifier les choses, on peut diviser l'histoire des commissions géologiques d'Afrique en deux périodes: la période coloniale et la période postcoloniale.

Comme celles d'autres parties du globe, les commissions géologiques d'Afrique ont été établies pour effectuer la cartographie géologique de différents territoires.

On les a chargées d'étudier et d'évaluer les ressources minérales et de faire état des résultats de leurs travaux sur le terrain et en laboratoire dans des rapports et cartes géologiques. Ce principal objectif reste encore de nos jours la raison d'être de la plupart des commissions géologiques du continent.

À l'époque coloniale, les commissions géologiques avaient les moyens voulus pour la cartographie géologique sur le terrain et l'exploration minérale. Les expéditions sur le terrain étaient difficiles, mais on disposait des moyens nécessaires pour les mener à bien. Les roches, minéraux et fossiles ramassés lors des expéditions étaient par la suite analysés au siège de la commission géologique, en Afrique, ou étaient expédiés à d'autres laboratoires en Angleterre, en France, en Belgique ou au Portugal, pour y être analysés par des experts. Les commissions géologiques ont obtenu des résultats remarquables pendant les vingt à trente premières années de leur existence. Plus de la moitié du continent a été cartographié et le cadre géologique du continent a été défini. De nombreux gîtes minéraux ont été découverts et plus tard exploités par des compagnies minières européennes. Les commissions géologiques africaines avaient une très grande importance économique pour les puissances coloniales, qui ont toujours veillé à ce que ces commissions reçoivent un financement suffisant. Les résultats justifiaient certes les investissements.

Quand les pays d'Afrique ont obtenu leur indépendance, le rôle des commissions géologiques n'a pas changé, mais leurs budgets ont baissé. Le matériel vétuste n'a pas été remplacé. Les rares véhicules dont on disposait pour les expéditions sur le terrain laissaient fort à désirer. Malheureusement, les commissions géologiques sont devenues des institutions bureaucratiques, et cette situation déplorable est encore celle qui prévaut dans la plupart des pays d'Afrique, à de très rares exceptions comme l'Afrique du Sud, le Botswana et l'Égypte.

Pour continuer d'exister en tant qu'institutions nationales, les commissions géologiques d'Afrique doivent changer d'optique. Elles doivent cesser de se concentrer sur la production de cartes et devenir des centres de mise en valeur des ressources minérales, qui, en plus des minéraux, doivent englober l'eau et les combustibles fossiles.

Pour s'acquitter de ce nouveau rôle, les commissions géologiques devront rechercher la coopération régionale afin de minimiser les dépenses et de maximiser les résultats. Il est impératif de disposer de laboratoires bien équipés et possédant le matériel d'analyse le plus moderne, une base de données informatisée et l'accès à des services de télédétection. La géologie a fait énormément de progrès au cours des dernières décennies. L'Afrique ne peut se permettre d'être à la traîne.

INTRODUCTION

I am going to be speaking very briefly on the evolution of geological surveys in Africa.

The history of geological surveys in Africa can be conveniently subdivided into two periods: the colonial period and the post colonial period.

African geological surveys, like their counterparts in other parts of the world were established to execute geological mapping of different territories. They were charged with the investigation and evaluation of mineral resources. Geological reports and maps were produced to record the results of field and laboratory investigations. This major objective still constitutes the "raison d'être" of most of the surveys in the continent.

During the colonial period, the geological surveys were adequately equipped for carrying out geological field mapping and exploration. Field conditions were difficult but facilities were provided to guarantee the success of field expeditions. The rocks, minerals and fossils collected during field campaigns were later analyzed at the Survey Headquarters in Africa or they were dispatched to "back-up" laboratories in England, France, Belgium, or

Portugal for further study by experts. Remarkable results were attained by the surveys in the first two to three decades of their existence. Over 50% of the continent, which is the second largest continental land mass on this planet, was mapped and the geological framework of the continent was defined. Many mineral deposits were found and later exploited by European mining companies. The geological surveys in Africa were of primary economic significance to the colonial masters and funding the surveys adequately was a priority. The results definitely justified the investment.

With political independence, the surveys did not change their role but the level of funding declined. Old equipment was not replaced. Field vehicles are either inadequate or non existent. The surveys unfortunately became bureaucratic institutions and this sad situation is still prevalent in most African countries today.

To continue to exist as national institutions, African geological surveys must change their outlook. They must evolve from the basic task of producing maps and become centres for mineral resources development. The mineral resources outlook must be broad-based and should include minerals, water and fossil fuels.

To achieve this new role, regional cooperation is necessary to minimize the financial out-lay and maximize the benefits. Well-equipped laboratories with up-to-date analytical equipment, computerized data bases and access to remote sensing facilities have become imperative. Geology has made tremendous progress in the last few decades and Africa cannot afford to be left behind.

In broad-line, the history of geological surveys in Africa is similar for most other countries but the details of development and achievement differ to a great extent. The geographic location of each country played a major determining role in the development of the geoscience sector. During the colonial period, the main emphasis was on geological mapping. The scale of mapping varied from region to region. In general forms it could be affirmed that eastern, northern and southern Africa were better mapped on much greater scales than west and central Africa.

Malawi, for example, is one of the best geologically-mapped countries in the continent, if not the world. It has a complete set of up-to-date geological maps, published at a scale of 1:100,000 with almost an equivalent number of accompanying descriptive bulletins and reports. On the other hand, parts of Nigeria are yet to be adequately surveyed and topographic maps are still not available everywhere in the country. The presence of economically valuable mineral resources was also an important factor as illustrated by the detailed large scale maps of mineral provinces, such as the Copper belt in Zambia and Zimbabwe and the Tin province of Jos Plateau in Nigeria.

COLONIAL ERA

During the Colonial Era the mineral potential of different parts of Africa was the principal factor that influenced the development of the geoscience sector. This is not surprising, as most of the countries were conquered and ruled initially by mining companies or trading companies interested in precious metals like gold and silver. Zambia and Zimbabwe were actually conquered and later governed by Cecil John Rhodes' British South Africa Company (BSAC). The development of most of the countries in southern Africa was also deeply affected by mining, whether for mineral exploitation, mineral transport routes or supply of labour to the mines.

In most of English-speaking Africa, the history of the geological surveys was more or less on the same pattern. Geological surveys were departments within the Ministry of Mines. Some organizational structures will be discussed later.

In former French colonies in west and central Africa the geological surveys or "Services Géologiques" were regionalized during the colonial era. There are two administrative offices in Dakar, Senegal and Brazaville, Congo, for west and central African territories respectively. After independence was attained, each country created its own "Services Géologiques" under a Director responsible for the administration of the "Direction des Mines et de la Géologie". One important point to note is the linkage of geology with mining in the former French colonial countries. This dual responsibility is responsible for the existence of the "Services Géologiques" within the framework of the "Bureau des Mines et de la Géologie". Geological mapping represents the major sector of activity and several field parties functioning under party chiefs were created. The field parties were later backed up by administrative and laboratory personnel. In the former British colonies in Africa, the set-up is different. During and after the colonial era, the geological surveys functioned under a Director who reports directly to the relevant Minister or administrative head of the ministry.

In Nigeria, the Geological Survey Department is one of the oldest in English-speaking Africa. It was established in 1911 by the Colonial Office after the conclusion of the assignment of the "Mineral Surveys Commission". The principal task of the geological survey is geological field mapping. In north Africa, the geological surveys have longer history and tradition than their counterparts in west, central and eastern Africa. The Egyptian Geological Survey is the oldest and most reputable. It was established in 1896 by H. G. Lyons and right from the beginning it was staffed by highly competent men whose published memoirs still remain among the best and most authentic records of geology of this part of the continent. The Egyptian Geological Survey and Mining Authority, as it is now known, is responsible for carrying out geological mapping and mineral exploration. It has direct shares in mining operations and is represented on the Boards of several mining companies.

In Morocco, the geological survey was established in 1912. In 1945 it was subdivided into three sections: Mineral Resources Investigations, Geological Mapping, and Hydrogeological Investigations. In 1960, the survey was transformed into a division within the Directorate of Mines and Geology. In 1978, it became a full-fledged directorate under a director charged with the responsibility of managing the following activities:
- geological mapping and related investigations onshore and offshore
- subsurface geological and structural investigations
- preparation of mineral resources inventories and other geoscience publications.

POST COLONIAL ERA

With the exception of a few countries, most of the geological surveys in Africa have witnessed drastic decline in their activities since the countries became independent.

This decline in activities is closely associated with the diminishing importance of the role of geological surveys. Armed conflict in many parts of Africa in post-colonial times also hampered the implementation of field mapping projects. This is generally true for the entire continent but was particularly noticeable in Uganda, Angola, Mozambique, Nigeria, Mauritania, Rwanda, Ethiopia, Somalia, Sierra-Leone, Liberia, Tchad and Zimbabwe. Other factors contributing to the decline in activities of the surveys include:
- limited Budget - (for field Programmes)
- absence of up-to-date field and analytical facilities
- man-power problems; insufficient number of geoscientists and technical staff.

There are obvious exceptions to the negative trend. The laboratory and library facilities of the geological surveys of Egypt, Morocco, Botswana and the republic of South Africa are very impressive by international standards, but these surveys also experience some man-power problems related to poor salary structures and the challenge from mining companies that offer better prospects to the experienced staff usually available in the surveys.

This decline of the surveys particularly in sub-Saharan Africa can only be arrested and reversed by a renewed awareness by governments of the importance of the geological surveys in national development. The responsibility for attaining this objective is mostly that of the geoscience community. It is necessary to re-define priorities and focus greater attention on aspects of the geosciences that were hitherto virtually neglected in the past. These aspects should include water resources, environmental geology, and the development of non-metallic or industrial minerals. It is also important to stress the absolute necessity for regional cooperation in the geoscience sector.

REGIONAL GROUPINGS

The history of regional economic cooperation in Africa dates back to the early years just before independence. The first economic unions were modelled after the European custom unions and common markets. These early attempts were short-lived because of the post-independence unstable political climate in most parts of the continent.

About ten years ago, the Economic Commission for Africa (ECA), recognizing the urgent need for regional cooperation if Africa's mineral resources were to be developed with minimum delay, initiated the establishment of two Regional Mineral Resources Development Centres at Dodoma in Tanzania and Brazaville in the Congo. Both institutions virtually failed to achieve the desired goals for the following reasons:
- lack of adequate interest and financial support by individual states in the region
- ack of adequate financial support from the ECA
- man-power difficulties
- wrong geographic location of the Institutions (particularly the one in Dodoma, Tanzania).

The very poor record of development of geological surveys in most African countries since independence in the 1960's is an indication of the need for a much more realistic approach to mineral resources development that will involve regional, systematic development and exploitation within the framework of multi-national economic programmes. This would have the additional advantage of strengthening inter-African economic development.

THE ASSOCIATION OF AFRICAN GEOLOGICAL SURVEYS (AAGS)

The association of African Geological Surveys (AAGS) is one of the bold steps taken to foster contacts and cooperation amongst the different national geological surveys in the continent. The two major objectives of the association are to:
- promote co-ordination on an international scale of geological maps
- develop a regular flow of geoscience information related to the African continent.

The Association is affiliated to the Commission for the Geological Map of the World (CGMW). Despite its initial achievements, the activities of the Association are now at an all-time low. The present diminished status of the association can also be attributed to the fact that it was motivated from outside the continent. The lesson here is that African countries must be prepared to motivate and initiate regional as well as international cooperation that is necessary to promote the development of the geoscience sector in the continent. Africa must be alive to her responsibilities.

There are 45 geological surveys in the continent of Africa and these 45 geological surveys, from the north of Africa right down to the south, can be subdivided into three categories:

- the big ones, like the ones in Egypt, Nigeria and South Africa, with about 100-500 geoscientists;
- the medium ones, like the ones in Morocco, Ghana and Kenya, with roughly from 50-100 geoscientists;and
- the small ones, like the ones in Togo and Swaziland, with three or four geoscientists.

One way out is for these national geological surveys to cooperate with each other and for the medium-size surveys to be strengthened financially and technically to become sub-regional geological survey Centres where geologists from the smaller Surveys can go and have good library and technical facilities. These sub-regional geological surveys should have adequate laboratory facilities, adequate library facilities, high-level back-up, scientific and technical staff, and adequate field facilities. The sub-regional surveys themselves should be linked up to Regional Mineral Resources Development Centres, one in Pretoria, for instance, for southern Africa, one in Lagos for west central Africa and one in Cairo for northern Africa. I think international cooperation would be easier if the international community could then link up with Regional Mineral Resources Centres in Africa and their effect can then go right down the scale.

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Latin American Geological Surveys: Regional Perspectives

C.O. Berbert[1]

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Abstract

The Latin American organizations which perform the role of geological surveys have each, according to their own country, a considerably different structure and are in variable stages of development, ranging from an incipient stage to a mature one. In some of these countries, no organization built along clearly defined lines can be found, but instead only groups of geologists belonging to universities perform geoscientific work comprising geological surveys usually in small scale. In other countries of the region, all geological activities are carried out by the same department that may also conduct mining inspection, regulation and statistics, just as the Geological Survey and the Bureau of Mines do. In this case, an example is SERNAGEOMIN in Chile. Most of the institutions in the region are really government agencies connected to a Ministry of Mines and Energy, Public Works and Communications, Infra-Structure or some other denomination. In Brazil, the activities of geological survey are performed by a company that is distinguished by its high technological development in the geoprocessing field.

Almost all geological surveys are very much concerned with environmental geology and it is considered by all of them as a priority for the future, especially as regards geological hazards, mining pollution, water pollution and urban expansion. In countries displaying major mining exploitation, the principal activities are connected with detailed studies on mining provinces, in order to increase the discovery of new deposits, such as Mexico, Chile and Peru. In these countries, intense geological surveys over a vast region (either employing geochemistry and geophysics or not) are limited. Brazil is an exception on account of a Regional Geological Mapping Program that has been in progress since 1985 in the 1:250,000 and also the 1:100,000 scale. This plan was made for 15 years.

All the agencies of the region believe that international technical scientific cooperation is of the utmost importance toward the development of the geosciences. As a result, mainly the larger countries of the region maintain a reciprocal exchange with institutions in Europe (France, England, Germany, Italy, Belgium), in North America (U.S., Canada) and in Asia (Japan). There has been an increase in the cooperation with China, Morocco, Angola and Mozambique in the last few years.

Résumé

Les organisations latino-américaines qui jouent le rôle de commission géologique ont, dans chaque pays, des structures très différentes étant parvenues à divers stades d'évolution, des plus simples

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aux plus développés. Dans quelques-uns de ces pays, il n'existe pas une organisation bien définie, mais il y a des groupes de géologues, *généralement liés à des universités, qui exécutent des travaux géoscientifiques, y compris des levés géologiques, presque toujours à petite échelle. Dans d'autres pays, les activités en géologie sont réalisées dans une seule institution, qui s'occupe aussi bien d'inspection minière, de réglementation que de statistiques minières, à la manière d'une commission géologique ou d'un bureau des mines, comme par exemple le SERNAGEOMIN du Chili. La plupart de ces institutions sont des organismes publics liés à des ministères des mines et de l'énergie, des travaux publics et des communications, de l'infrastructure et d'autres semblables. Au Brésil, les activités de la commission géologique sont exécutées par une compagnie, caractérisée par un grand développement technologique dans le traitement des données géoscientifiques.*

La géologie de l'environnement est une préoccupation de presque toutes les commissions géologiques et est en train de devenir, chez chacune d'elles, une priorité pour l'avenir, spécialement en ce qui concerne les risques géologiques, la pollution causée par l'exploitation minière, la pollution des eaux et l'expansion urbaine. Dans les pays avec une forte exploitation minière les activités les plus importantes sont liées à des études détaillées des provinces minières et ont pour but d'augmenter les réserves ou de découvrir des nouveaux gîtes, comme au Mexique, au Chili et au Pérou. Dans ces pays, les levés géologiques détaillés sur de vastes régions (employant ou non la géochimie et la géophysique) sont limités. Le Brésil est une exception et développe, depuis 1985, un programme de levés géologiques régionaux, à l'échelle de 1/250 000 et 1/100 000, devant s'étendre sur une période de quinze ans.

Toutes les organisations de la région considèrent que la coopération technico-scientifique internationale est d'une grande importance pour le développement des sciences de la Terre et principalement les plus grands pays de la région soutiennent des accords avec des institutions de l'Europe (France, Angleterre, Allemagne, Italie, Belgique), de l'Amérique du Nord (États-Unis, Canada) et de l'Asie (Japon). Au cours des dernières années, il y a eu un accroissement de la coopération avec la Chine, le Maroc, l'Angola et le Mozambique.

I would like to congratulate the organizers of this conference which has given us the opportunity to exchange knowledge with our survey colleagues and to reflect about our roles in the development of mankind. In preparing this paper I felt as if I were part of the Tower of Babel: the Tower in the Bible where everybody spoke different languages. I received information from the Latin American Caribbean surveys in English, French, Spanish, and a little bit of Dutch. None of these languages is my native tongue. In Brazil we speak Portuguese. In the last few days, you have listened to different pronunciations of English . We have listened to German-sounding English , French English, and Chinese and Australian English. I'll give you the opportunity to listen to Brazilian English.

Latin America and the Caribbean comprise more than 30 countries covering over 30 million square km with different cultures, customs and philosophies. The geological institutions in the area have different structures and are in different stages of development. Some are very young institutions having groups of geologists at universities performing geoscientific studies. Other institutions are quite well developed organizations with over hundreds of geologists. That's the case for Brazil. In our institution we have almost 400 geologists. Some of these institutions are relatively old and suffered many reforms during their existence. Today they are still evolving, due to political changes, the new challenges of environmental pressures and social necessity.

Geological surveys in Latin America may be organized as departments or equivalents subordinate to a General Directorate or Commission under which are also departments or equivalents in charge of mining control, regulation, economic minerals, and statistics. Normally in this case mining is the first priority in the organization, and geological activities become secondary or restricted to mining areas and receive less attention in the budget. These institutions comprise the largest part of the Latin America and Caribbean surveys, including Chile, Ecuador, Guyana, Mexico, Paraguay, Peru, El Salvador, Venezuela and Uruguay.

Another type of institution is organized independently, but performs the role of a national geological survey. In these cases the Bureau of Mines and the Geological Survey are usually under the same ministry, which may be that of Mines and Energy, or Public Works and Communications, or Infrastructure, or Interior etc.

Brazil is an example of the latter form of organization. Until two years ago, the National Department of Minerals Production (DNPM) was in charge of the mining control, regulation, authorization and concessions for exploration and exploitation activities, economics, minerals and statistics, and geological services. Geological mapping was done by a parastatal organization under contract, the Minerals Resources Research Company (CPRM), which also carried out the mineral prospecting and exploration with budgets from the Ministry of Mines and Energy. In

January 1991 CPRM assumed all the activities and responsibilities of the Brazilian Geological Survey, while DNPM remained as a Bureau of Mines. This was the situation until recently, when a new reform of the Brazilian ministries split the Ministry of Infrastructure into two Ministries - Transportation and Communication, and Mines and Energy.

The new Ministry of Mines and Energy has two different secretariats, the Secretariat of Mines and Metallurgy, and the Secretariat of Energy. CPRM is subordinate to that Ministry, through the Secretariat of Mines and Metallurgy. CPRM's activities are approved and controlled by an Administrative Council, to which the Executive Directory is subordinate. CPRM has two technical directors, one administrative director, two superintendants, and eight regional offices (regional superintendencies).

CPRM has four major functions. These include staffing the regional offices in Brazil in the main state capitals, conducting basic surveys on geology and hydrology, prospecting for minerals, and conducting special projects including environmental protection and data processing. CPRM also carries out activities in foreign countries under commercial contracts or under terms of scientific cooperation.

The Directorate of Geology and Hydrological Resources is in charge of the geological mapping of the country, the hydrological resources of the country and the due processing in the company.

The Minerals Research Directorate is in charge of mineral prospecting and also conducts special projects, especially drilling, and activities in other countries.

This kind of organization has been successful. In the last twenty-two years CPRM has discovered some of the largest mineral deposits in Brazil and transferred the mining rights to the private sector. Minerals such as tin (the largest tin mine in the world), phosphate, copper, nickel and so on have been discovered. Similar activities are executed by the geological organizations of Bolivia, Cuba and Colombia.

All the institutions which answered my questionnaire recognized that the immediate objective of their surveys is to attend to social priorities. All of them are concerned with executing projects in environmental, and hydrogeological areas, and in geological mapping as a way to know the soil and subsoil potential for agriculture, raw materials, and mining in general. In the countries of the Pacific Coast, the discovery of new metal deposits is more important.

There is a preoccupation with organizing national geological, hydrological, and geophysical maps. Information processing is not advanced, with the exception of Brazil where CPRM maintains a large geographical information system with many data banks for free consultation by the public. Thus the main priorities in Latin America are the national maps, basic geology, geochemicals, geophysics, mineral prospecting and exploration. In some cases, such as Brazil, hydrogeology is important. Others stress environmental geology. However, no one knows really how to start work in this area. Other activities include metallurgy and applied geology. Some of the geological surveys, such as the Guyanese Geological Survey, also mine and market mineral production.

In some countries, chemical and metallurgical laboratories are maintained by the geological and mining institutions as a way of conducting mining activities. In other countries, laboratories are poorly equipped and sophisticated analyses and studies have to be made outside.

The Latin American Geological Surveys have a long history of technical cooperation with other countries. However, cooperation in Latin America is usually one-way: we receive the cooperation from the industrialized countries, and usually we don't contribute, in fact, with our own experience. The main countries with a tradition of cooperation with Latin America and the Caribbean are US, Canada, Japan, the UK, France, and Germany. Others are Spain, Italy, Belgium, Sweden, South Africa and, recently, China, Morocco, and other countries in Africa. We don't cooperate much among ourselves. We have lots of experience to be exchanged between our countries, but we really don't. It's much easier to get cooperation, to get communication with countries from the northern hemisphere than among ourselves. It's a case of culture, I guess.

Cooperation includes training abroad, donations in-kind, and joint execution of projects, mainly geological mapping projects.

To analyze the future, I should cite some problems. The first problem in our geological surveys, not only in Latin America but for all countries, is communication with politicians and society as a whole. Geologists know how to talk to themselves, to their groups, to the surrounding groups, but not to society, nor to politicians. This was expressed two or three times here. Inadequate communication brings discontinuity of programs. This in turn brings insufficient financial resources for the programs. And this stops the projects. So if you don't have adequate communication, you don't have the support of society.

Solutions for that are to integrate programs and cooperate with other institutions and organizations; and to train people from universities in our institutions in cooperative programs with the scientific institutions and through education.

In Latin America and elsewhere, we have many ways to change our situation, to be recognized by society and by the politicians. Mining will continue to be a priority in Latin America. The Amazon is a big region, an unknown region, not adequately geologically mapped. It comprises more than 7 million square km, comparable to Australia in size, and is completely unknown. It covers areas of many countries of South America. This region could hold more than 46 Englands. Alternatively it is many times the size of Europe. We have to search, we have to map, we have to know the mineral potential of this area. It's not easy. It's almost totally covered by jungle or high forest. Many areas for gold mining are being discovered there.

But mining cannot be the only priority for our surveys. I think we have to change our direction from minerals. We have to show society that agriculture depends on minerals and that raw materials for construction are important. We have to turn outward, recognizing that society plays an important role. Otherwise I think we are going to be erased, we geologists, extinct in the next ten years. I'm pretty sure of this. We must be sure that we work together with respect to environmental matters.

So I think things for us in Latin America and for the rest of the geological surveys in the world that I heard here are bleak. We can change this if we reflect about our role in society.

I would like to congratulate the Geological Survey of Canada in my name, in the name of the Brazilian Geological Survey (CPRM), and in the name of all the directors and presidents of Geological Surveys of Latin America and the Caribbean, for the 150th anniversary. I'm very proud to be here commemorating this with you people from the Geological Survey of Canada. I'm very honoured to be invited for this conference.

Regional Perspectives Discussion

Unidentified Speaker: A common theme that we've heard has been declining financial support and the scarcity that each country seems to face. What is the situation in China in terms of financial support for the geological program?

Zhu Xun: In China financial support for geological work comes from the government. Every year 4 billion renminbi are invested in the geological sector, but only half gets to our ministry. So the Ministry of Geology and Mineral Resources every year gets investment of 2 billion renminbi.

A. Darnley: As far as geochemical mapping was concerned, progress in China in connection with systematic geochemical mapping has been truly remarkable. Over the last ten years it has progressed from less than 5% to 50% with systematic mapping. I'm very happy to present the results of this wherever I go as an example of what can be achieved by this sort of energetic approach. In relation to what was said about Africa, the International Geochemical Mapping Project is endeavouring, by setting up of regional groups, to encourage national geological surveys to work together. They are considering holding training workshops to develop local talents and tackle problems of both economic and environmental aspects of the earth sciences.

P.J. Cook: I'm glad to see that Cornelius Kogbe gave a much higher profile to the environmental side, because in the last two years I've seen a very noticeable increase in the amount of effort the aid agencies are prepared to put into the geoscience aspects of the environment. His suggestion of regional geological centres is very good. But a difficulty with this is that generally it's a lot easier to get aid on a bilateral basis. A multilateral situation has increased difficulty, so there is a real practical problem for many countries. Also, the pressure has to come from the countries themselves. It's no good for us to think we should offer geological aid to Zimbabwe, for example. Zimbabwe has to approach the aid agencies, who would be pleased to react to them.

G.O. Kesse: I agree with Dr. Kogbe about this weakness, but who is going to be responsible?

C.A. Kogbe: The time has come for African governments to take initiatives in their own interest. One of those initiatives is to provide our politicians with the necessary information and the logic behind our reasoning. Then they will be able to see that setting up regional institutions is in the interests of their country and of the region. They will have to put their own seed money into it and establish institutions. These institutions can be built around existing surveys. For instance, the surveys in Egypt, Pretoria, or Lagos can constitute the nucleus of some of these regional centres

REPORTS OF COMMENTATORS

Theme I: Evolution of Geological Surveys

J.O. Carlsson and G.O. Kesse

Theme II: Reconciliation of Resources vs. Environment

B. Skinner

Theme III: Resources for Society

J. MCOuat

Theme IV: New Concepts and Technologies

V. Sattran

Theme V: International Communication, Cooperation and Collaboration

D. Ross

The Evolution of Geological Surveys, Part I

J.O. Carlsson[1]

This is obviously a time when geological surveys have to adapt themselves to new situations from many points of view. It's a time of transition. Transition is not a question only of saying that, for example, environmental issues play a more important role in society and that we have to adapt to that. Questions of environmental issues, land use, assets and risks, sustainable natural resources management, groundwater supply, etc. create new challenges. Further, governments are changing their attitudes from just allocating funds and leaving to us the strategical issues on what should be done, for what purpose, on what level, at what cost, and in what time span. Instead, governments have started setting targets, quantitative as well as qualitative. And they want us to be measured or judged against the targets they have set, not against our own targets. Governments demand us to generate funds for ourselves, and so on, and so on.

I regret that in a conference on Geological Surveys in the 21st Century more time could not be devoted to those crucial questions of how to tackle the changing prerequisites for and demands on geological surveys. Peter Cook made a review of how the British Geological Survey is adapting itself to new demands and prerequisites. This adaptation is a continuous process. Peter Cook is really open minded in facing new situations. He is raising hard questions. To some he might be using bad words in church, but he is really raising questions which we will all have to deal with, because our objectives are given by society not by ourselves.

In his full paper that he didn't have time to read yesterday, he said that in the view of the British Survey, a more businesslike approach is not only competitive with good science but can in fact enhance it. Furthermore, many of the basic tenets of the Survey have been questioned by those outside the Survey and the view that the Survey knows best what it should be doing is no longer an acceptable dogma. The customer is now the arbiter of what is required from the Survey and either we adapt or we wither on the vine. There could be a downside if the Survey was no longer to carry on contract science, most notably because it is unlikely that any government would provide public funds to make up for any loss of funds from the private sector. It has to be acknowledged that contract science has brought with it the discipline of a businesslike approach, and the need for quality assurance and quality control. Quality today is measured from the point of view of the customer, not from the point of view of the producer. A loss will result from breaking off the strong links that have developed between customers and the Survey, and from the potential loss of relevance. I strongly recommend his full text to be read carefully. The words will have a bearing upon geological surveys in the 21st century.

Ray Price underlined the need for adapting the geoscience information available at geological surveys to the requirements of society. This means not only that the required information is supplied in a way that suits the customer, but also that the kind of information and all products fit with the requirements of the customer. This means that our core operation has to be adapted to the requirements of the customers.

It might be useful to clarify the difference between a customer-oriented activity and a supply-oriented activity. In a customer-oriented organization which starts with customer problems, those problems might be solved by producing a set of products. Those products call for certain specific geological information to be available. That decides what operation, what core activity, should be undertaken by the Survey. In the last step, that decides what competence must be available, and how it should be organized.

The other organization – the supply-oriented organization – starts with existing staff and they decide what core activities should be undertaken. That decides and limits what geological information will be available. That then decides and limits what products could be produced by the organization, and in the last step, what problems can be solved. In a supply-oriented organization the customer is supposed to adapt to what the organization wants to produce.

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Other important issues dealt with were, for example, the balance between core programs and commissioned activities. There is a growing potential for geophysics, geochemistry and geochronology, together with a growing need for competence in physics and chemistry. Furthermore there is a need for an R&D activity aimed at underpinning the continuous development of competence.

Mr. Johan of France presented an interesting model for interaction with a university system.

Finally, regarding the importance of integrated and interactive data bases, Dallas Peck demanded that we tear down the walls between disciplines. There is also the difficult challenge to make geology visible.

The Evolution of Geological Surveys, Part II

G.O. Kesse[1]

I, first of all, wish to add my voice to all who have expressed their thanks to the Geological Survey of Canada (GSC) for having been invited to participate in the 150th anniversary of the GSC and to this most significant International Conference of Geological Surveys. I wish GSC well in the years ahead.

Yesterday we had the privilege of hearing from state and provincial geological surveys from three countries, that is Australia, Canada and the United States of America.

In Australia, the establishment of the state geological surveys long preceded the establishment of any national geoscience agency. For example, the Geological Survey of Victoria was established in 1852, Queensland in 1868, New South Wales in 1875, South Australia in 1882, Tasmania in 1883 and Western Australia in 1888. Although the Federation of the Colonies to form the Commonwealth of Australia took place in 1901, it was not until 1946 that the Commonwealth Bureau of Mineral Resources, Geology and Geophysics (BMR) was established, and since then has functioned essentially as a national Geological Survey. In 1978, the Northern Territory Geological Survey was also established.

Before 1946, that is before the formation of BMR, the Australian Constitution allowed mineral rights to belong to or remain with the states. Geological survey work was therefore seen as a state rather than commonwealth responsibility. In 1946, that is just after the Second World War, the need for a national organization to facilitate geological mapping of the continent, as well as to advise the commonwealth government on earth resources issues, was decided. Hence the formation of BMR. The other federal agency with responsibilities in geoscience is the Commonwealth Scientific and Industrial Research Organization (CSIRO). These organizations became involved in minerals research in 1926.

The primary role of each state or territory geological survey is to record and interpret the geology of its state or territory, to provide the results to government and industry and the general public, and to advise on relevant environmental land use and resource issues. The state surveys concentrate mainly on geological mapping although they conduct detailed research in fields such as structural geology, petrology, the regolith, environmental geology, geochronology, data base development, etc.

The BMR, on the other hand, functions as the adviser to the government, industry and the general public on the geology of the continent and on various environment, land-use and resources issues and their development, which are of national interest. The BMR is also responsible for geoscientific work in Australia's Antarctic Territory and various island territories. The BMR has also a greater role in offshore geology. However, day-to-day administration of offshore minerals and petroleum has been delegated through legislation to their respective state and territory governments.

The BMR research role is also field-oriented and mapping is carried out in close cooperation with the state geological surveys on the National Geoscience Mapping Accord, which is coordinated by the annual conference of chief government geologists. Under the terms of this Accord, a programme to produce a new generation of geoscientific maps of the continent is being shared by BMR and the geological surveys of the states. BMR also conducts detailed research in the categories listed above for the state geological surveys. BMR, however, focuses on areas of national importance. BMR is responsible for extensive geophysical data acquisition and processing, especially through seismic and air-borne geophysical surveys. BMR has also primary responsibility for earthquake and geomagnetic monitoring throughout Australia. CSIRO's principal new geoscientific research is now carried out in four divisions:

- the Division of Exploration in Geoscience;
- the Division of Geomechanics;
- the Division of Water Resources; and
- the Division of Soils.

Although mapping and geoscience data handling are the most important functions of the state geological surveys

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and the BMR, from the point of view of mining and petroleum industries, lack of sufficient resources is of late ffecting the levels of service, especially with regards to mapping. It is felt that the lack of sufficient inputs for mapping, if not reversed, is likely to have long-term adverse effects on the nation's largest industry, that is mining, environmental management and land-use planning.

As compared to Australia, the founding of the provincial/territorial geological surveys of Canada was preceded by that of the Geological Survey of Canada; the oldest one among them, that is the New Brunswick Survey, was founded in 1846, followed by that of Newfoundland (1864), Nova Scotia (1865), Ontario (1891), British Columbia(1895), etc. The youngest one is that of Saskatchewan(1931).

Since their inception, the provincial surveys have maintained a close working relationship with the private sector and have fully concentrated their efforts almost entirely on supporting mineral exploration and development by providing detailed geological maps and reports of prospective areas. They have also systematically documented mineral deposits and have given advice to prospectors on where and how best to look for various types of mineralization or mineral commodities. The emphasis that was given to the various programmes varied across the country.

All the provinces have maintained geological survey organizations. However, these vary considerably in size and range of activity. The scope and scale of each survey's operations are determined both by their populations\tax base and the peculiarities of the terrain and resource potential encompassed by their provincial boundaries. For example, some geological surveys possess large hardrock contingents, and therefore the work carried out must of necessity be biased towards belts or terrains with higher mineral potential whilst other surveys show a bias towards Phanerozoic subsurface investigations. Some, however, maintain a balance of the two.

Typically, petroleum and water resources are excluded from the sphere of concerns addressed by the provincial geological surveys with the exception of Saskatchewan and Alberta. Some provinces maintain separate Water Resources Branches within the Department of Environment or Natural Resources. Most provincial surveys include surficial geology sections, are involved in land-use issues, and also have industrial mineral units. Mineral Exploration Liaison Committees are maintained by all the provinces with representations from various industry groups and the Geological Survey of Canada. Linkages and cooperative research are well established with university groups and several provinces support research councils or institutes whose activities augment those of the geological surveys.

During the 1990's, the provincial geological surveys will have to address the following issues:

1) environmental geological hazards and land-use concerns;
2) an elevated level of cooperative inter-agency program delivery;
3) the need to upgrade archival data bases for compatibility with electronic processing techniques;
4) more rapid turnaround for map and report production; and
5) more and effective widespread representation on intergovernmental and interagency industrial development committees.

It is also felt that the surveys must communicate more effectively with industrial clientele, with the public and with decision makers both in the government and in the private sector. This will make their work be appreciated in the context of solving the problems confronting society.

All in all, it can be said that Canada's provincial and territorial survey organizations have played a unique role in facilitating, coordinating and cultivating an enhanced awareness of the proven and potential value of each region's mineral and energy endowment.

Like its counterpart in Australia, at least, 36 state surveys in the US preceded the founding of the USGS - the United States Geological Survey - which was founded in 1879, the first geological survey having been founded in 1823 in North Carolina. At present, all the 50 states of the U.S. have state geological surveys. All these have the common responsibility to delineate the geologic framework and mineral resources of their respective states as they relate to the environment and economy. The state surveys range in size from a staff of 146 in the state of Illinois to one in the states of Massachusetts and Rhode Island. The total staff of the 50 state geological surveys is 2,162, and operating budgets amount to a total of $129 million, of which $15 million is contributed by the federal agencies.

At present, environmental matters are probably the major political justification for the surveys' continued existence, as they are all involved in waste-disposal siting, geological-hazard delineation, mined land reclamation, radon mapping, power plant siting, transportation routing, groundwater pollution mitigation and land use planning.

Fundamental to the programmes of the state geological surveys is the recognition that detailed geological mapping is the foundation of all geological research, be it scientific or applied. The withdrawal of geologists from the field into laboratories has strongly been opposed by the Association of American State Geologists, and it is reported that about 2 weeks ago the National Geological Mapping Act was passed by the U.S. Congress. In summary, the 50 state geological surveys constitute a dynamic developing geological community, proud to be functioning at the interface of scientific progress and public needs and proud of their 160 years of existence and achievement.

Apart from the Canadian surveys, it is interesting to note that the state surveys in Australia and the U.S. are much older than the federal surveys, and their activities have no doubt had a bearing on the usefulness of the federal surveys. All the surveys were, at first, concerned with geological mapping. It is recognized that although a shift in the activities has been towards environmental geology, the use of basic geological mapping to a survey cannot be overemphasized. It is also significant that the Association of American State Geologists is taking the lead in mounting a concerted educational and political effort to address the need for authorizing and funding detailed geological mapping by the states surveys as well as by the U.S. Geological Survey. We all must be concerned with the environment; however the need for geological mapping is a must. There must be cooperation between the various state surveys and the federal surveys. We cannot talk of international cooperation if there is none within the same country. It is interesting that even with, at times, limited human and material resources, the state surveys have been able to achieve high standards in their work. This is a lesson to all surveys all over the world, particularly now that most countries are experiencing economic difficulties. Another point to note is the close working relationships between the state surveys and the private sector, especially in the field of mineral exploration. It is obvious that the state surveys have an advantage in that they have a firmer footing in their states as compared to the federal surveys. One obvious point is the linkage between the size of the state surveys and the range of their capabilities. The bigger federal surveys seem to have lesser financial constraints and are therefore able to cope with bigger and much more diversified work loads.

Resource development versus environmental protection: An argument in favor of an association of geological surveys.

B.J. Skinner[1]

Although almost every speaker has addressed one or more aspects of mineral production and the environment, I cannot, in the few minutes that I am allotted, revisit all of the points raised in these elegant papers. So I'm going to have to generalize to a certain extent.

Speaker after speaker reaffirmed that the central mission of a geological survey is the assessment of the mineral endowment in the area under its charge plus an assessment of development [as a basis] by which more efficient exploration for minerals can be carried out. Many speakers also identified concerns for the environment as growing issues. The BGS and the BMR even provided intriguing examples of large-scale programs that started as mineral exploration programs or aids to mineral exploration and then became components of an environmental monitoring program. The BGS model was regional geochemical mapping, and the specific example provided by Peter Cook was lead contamination in some of the valleys in Scotland. Regional geochemical mapping, incidentally, is a program that was recommended by the ICSU group to UNCED (Rio '92) as a valuable environmental monitoring tool. The BMR example cited by Neil Williams was radiometric mapping and the extraordinary detail it can provide concerning erosion and sediment transport in a difficult terrain such as the region around Cape York in Australia.

I concluded from the presentations that while some surveys and their sister agencies have well-developed plans for environmental action, many others are still grappling with the environmental issue and are not quite sure where to turn nor how to move ahead.

Mining was identified once or twice as a major villain in degradation of the environment. This creates a dilemma because the assessment and exploration aims of a survey are designed to help the very industry that must be environmentally monitored. It is true that mining can devastate the landscape, and I want to give you a couple of examples, but mining is not all bad. The first example is a gold mine in New Guinea - Mt. Victor. Because the mining activity was in an area of high rainfall, steep terrain, and deep weathering, it is practically impossible to return the landscape to its original position. Mt. Victor, which is now closed, observed all possible prevention steps; nevertheless, considerable environmental degradation was the result. Mt. Victor is an example of having to balance certain and unavoidable degradation against production of a desired commodity

A second example is Serra Bellada, a Brazilian gold mine. When the mining started the government restricted work to small claim holders. Under such circumstances it's impossible to maintain any environmental control where a horde of people crawl endlessly over a deeply weathered, high rainfall terrain. This case has produced not only a human environment problem, but also a regional environment problem. Serra Pellada is an example of an environmental problem being created as a result of government action.

My third example is old mine areas worked by companies long gone. At one unreclaimed mining site at Leadville in Colorado at over 10,000 feet altitude, mining was completed over 50 years ago, yet the spoil heaps have sat untended because they are no one's responsibility. At another site, in Illinois, coal mining spoils have sat for about 45 years. In the long run the reclamation of such areas are a public responsibility.

Most mined land can, of course, be reclaimed if restoration is planned ahead. The area around Fairfield, Texas, not far from Dallas, is one of brown-coal mining. The brown coal is used for power production. As the area is mined restoration steps are taken by installation of adequate drainage. Restored land looks very much like the original. You might be interested to know that the carrying capacity of cattle on the unmined land was one-quarter of the carrying capacity on some of the reclaimed land, even ten years after reclamation.

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Part of the environmental issue is planning. Slowly, too slowly in many countries, environmental monitoring and stabilizing are becoming part and parcel of mine development. Dr. Naldrett raised this issue of slowness with what to me were dramatic words when he remarked, "Is green in Canada worth it, if it means brown in Chile?" And that sort of question, I suggest, is one potent reason why geological surveys of the world should initiate an ongoing international association. By doing so you could help ameliorate, possibly even prevent, unintentional environmental disasters from happening.

A disaster that I believe is waiting to happen is on Lihir Island, just north of New Guinea. It is a volcanic island. In the caldera is one of the largest and richest gold deposits discovered in recent years. The planned pit is to be 300 m deep and dug into rocks that have temperatures on the order of 140°C. The barrier between the sea, which is narrow, is going to be a few tens of meters, and it will have an elevation above sea level of only about 5 or 6 m -all of this according to the Annual Report from the mining company that proposes to open the pit. If you look at the cyclone distribution and frequency maps of the world, you will see that Lihir Island is right at the center of the region subject to the most violent and the highest frequency cyclones in the world. You can imagine what it might be like down a pit 300 m deep when a cyclone comes along and your barrier is only about 5 or 6 m high from the sea. The mine has not been started. I hope it isn't.

No one at the meeting has, so far, focused attention on what I believe are the two big issues that underlie all issues of mineral production and environment, and therefore concern all surveys. They are the issues of conspicuous consumption and growing population. So I'm going to close by attempting to focus briefly on those two questions.

We in the developed world stand accused, perhaps rightly so, of conspicuous consumption. Depending on how you count it, of a total of 5 1/2 billion people in the world, the one billion people who live in the industrial world use between 15 and 20 metric tons of mineral resources per person per year. How do we use it? Each of us has a stock of about 500 t of material in use. By that I mean there is material we use repeatedly - public buildings, roadways, transportation systems, and so forth - that has a long life. That calculation is from a relatively simple estimate that I've made and it might be off by 100 t or so per person. Of the 15 t per person used each year, I estimate about 10 t are used to maintain and repair the existing stock. It's about 2% for service. That's not conspicuous consumption. The remaining 5 t is where we can cut. Short of dismantling society, we are not likely to diminish our consumption rates very much. We can do it a little, but not very much. Our charge, then, must be to help the other 4 1/2 billion to have an equal or equivalent stock in use so that they too can enjoy the highest standard of living.

The earth can probably stand the strain if we build up the stock carefully and responsibly. That's part of the message of the Brundtland Commission. What the earth cannot stand is a population that grows at the present rate of 95 million new bodies, births above deaths, every year. That's three new people every second. Therein lies the core of the environmental problem. A stable population can entertain hope. An exploding population has very little hope because an already difficult problem becomes daily worse.

Take all the land above sea level, and exclude that part that's covered by permanent ice, and that part of the earth that's above 5,000 m, where we can't really live. That leaves everybody today having what I call a support square of 160 m on a side - that's all the land you've got. Of that support square, only a fraction, 53 m on an edge, is woodland or arable in any way (the estimates of arability come from FAO). Only 33 m is sufficiently arable for growing food. These scraps of land shrink in the face of a population that will expand by the year 2025 to 9 1/2 billion if all we do is simply reproduce the people alive today. If we exceed the replacement rate the population will be even larger.

The atmosphere and the hydrosphere are not the only parts of the global commons that we all must share and for which we must harbor environmental concerns. We know that we've strained the atmosphere and the hydrosphere. We're all concerned about them. But the regolith, too, is part of the global commons. The group that is best trained above all to understand the fragility of the regolith is the geological community. It's time we spoke out and pointed out that this fragile common resource is also under stress.

I would close then in urging the geological surveys of the world to take responsibility for this least attended unit of the global commons, the regolith. Its buffering limits may be large but they are not infinite. That, I suggest, is the global theme around which you should join in a newly formed association.

Resources for Society

J. McOuat[1]

I very much appreciate the invitation to speak with you and to have learned so much in the last two or three days. One of the things that makes me a little unusual is that I am one of your "customers". I represent the mining industry and because of the nature of our firm's work (we've worked in some 65 countries) I've been a customer of a number of you from time to time. You may want to look at me also as perhaps one of the last of a kind, being a Canadian explorationist. This industry is emigrating at a fairly rapid pace, unfortunately. While I am a geologist, no one has ever paid me to be a geologist. They've paid me to find more money in the ground than it costs to dig it out. You fellows represent my source of basic information, and boy do I appreciate it. I wish there were a few politicians that knew how hard it is to find a mine, and how much we rely upon you.

The theme that I'm talking about this morning is *Resources for Society*. I found this particularly interesting in view of Ray Price's stark comments regarding world population doubling in his working lifetime. We just had another example of the serious problem we're facing protecting our own living standards and improving those of others. Drs. Kursten and Wellmer made a number of points I'd like to comment upon.

The first point is that there is no decoupling of metals versus GNP. This presumably means more metals will be needed by the industrialized societies if they intend to increase their GNP. It also means there will be a rapid growth worldwide in metals used, particularly as the developing countries approach our living standards. More is needed, and user-importer nations are under enormous national pressure to recycle materials. There is a better opportunity to do this with metals than with most other commodities. I also wonder if the producer nations should be really under the same pressure to recycle as the consumer nations, or simply should we ship back our used vehicles to recycling nations for them to recycle because they will develop these skills.

Mineral prices have not risen in constant dollar terms. Therefore, your science base and my industry have done our job for the world. We have been able to maintain production, an adequate supply, in the face of rapidly increasing demands without real price increases. We have done so by discovery, productivity, technology improvements and overall efficiencies. This may change, certainly in the developed countries, as mines' real costs are rapidly rising, due to permitting, reclamation, rising risk/reward ratios, and environmental impact assessments. I wonder if real prices have risen for bulk tonnage commodities such as sand gravel, cement, etc., or simply will rise as accessible deposits are worked out, with consumers, as distinct from producers, facing a real cost rise, because of transportation.

The volume-space concept introduced was very interesting. The only parallel I can think of in Canada, for example, is the dispute between the City of Timmins and the Government of Ontario, where the City of Toronto is quite happy to ship their garbage north, Timmins is quite happy to take it into abandoned mines, and the province won't let either of them do the kind of thing the Germans are already doing.

Global competition for mineral markets and world pricing has always been a fact of life for the Canadian mining industry. It would appear that Germany at least, and perhaps Japan as well, are prepared to let their mining industries compete and not have protection available to them in the national interest as so many countries do with their food supplies.

Waste disposal is a new task for geological surveys. Water management is also a newer task for geological surveys. I wonder if there are items such as environmental audits that should be undertaken by geological surveys? Are there reclamation policies which should be done by geological surveys, or reclamation monitoring, or establishment of reclamation criteria? I don't see the geological surveys being much involved in these matters.

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Regarding advanced materials - new products create new demand for different minerals and new specifications for these are established. However, from the point of view of the geological surveys and mineral explorers, the new demand is small, even if it is growing very rapidly. The market is uncertain in its specifications, and one world class deposit may dominate the total market. Industrial minerals and rare earths have historically been viewed this way. Geological surveys and the mining industry rely upon the old standards. New products and whether they are environmentally sound are not a feature of our interest at this point in time, at least in my opinion.

Resources for Society: This means business as usual for the geological surveys, business as usual for the mining industries. Populations are increasing. People have aspirations for improved living conditions, and the consumption in fully developed countries is still rising. It's a good thing that there's recycling. We probably couldn't meet the demand if there weren't.

Some general comments: Surveys in countries like Canada, Australia and the US, the traditional big three in mineral production, are being saddled with more responsibility and less funds. Environmental and land use demands are up. Mapping and research, therefore, has to go down. This won't work; geological surveys are now in the public eye as not since the days of geological heroes, when geologists were identified as grand explorers, creators of wealth, and not just pillagers or rapers of the earth. The problem today is that we have an appallingly ignorant public. The only voice that I know that has reached the public is an author from the US, John McPhee. He is a very well known writer but I doubt if many of you have read his books.

Aside from interests of pure science, the geological survey's role was to assist the mining industry in the discovery of mineral deposits, improve living standards, and create national wealth. Today you are asked to improve living standards principally on the basis of environmental protection; the creation of wealth is secondary. This leads me to conclude there are three kinds of Geological Surveys today in this room: Germany and Japan - mature societies focusing on quarrying, waste control, water and geohazards; Canada, Australia and the US - the same as the above, plus mapping, research and discovery of mineral deposits. The ones we've heard little from and the ones that face the real problem are the developing countries. They have absolutely all they can do to be a conventional or traditional geological survey. They are underfunded. In addition they are being overwhelmed by mining exploration companies and mining development companies. Their task is very daunting. Our job is to assist them in establishing their mines and their mining industry.

I didn't hear much about the long-term impact and major decline in field mapping. A hundred years from today, will we be using today's maps? A couple of years ago we ran a program in Scotland and we had a map dated 1875 as our base.

Another problem we have in the geological surveys in the industrialized countries at least, is that the population is aging and the employment opportunities are declining as the mapping funding is reduced. I wonder about the education of our replacements. I wonder about the position of the surveys regarding land withdrawals. Do you think this is a good thing? Do you think work should be done on them before they are withdrawn? Should the surveys be taking public positions on this matter?

The traditional justification for the existence of surveys in Canada, Australia and the US goes down as their mineral industry is being exported. How are you going to handle that? Currently in the mining world, there is an international bidding war for the limited resources that the mining industry has to deploy in either exploration or production. The three traditional leaders of standards, leaders of ethics if you will, are seeing their mineral base eroded in favour of the developing countries. Surely the geological surveys should be in a position to assist each other with this transition.

New Concepts and Technologies in the Earth Sciences

V. Sattran[1]

Mr. Chairman, ladies and gentleman, I feel honoured to be able to participate at this important conference and I would like to join others in congratulating the Geological Survey of Canada at the occasion of its 150 anniversary. I will try to do my best to summarize the highlights of the two excellent presentations of Drs. Ogawa and Williams.

The twentieth century signifies new concepts for Earth sciences. We have extremely rapid development of analytical methods in geochemistry, of airborne geophysics and of the computerization of data with modelling of three-dimensional and multi-dimensional programs. Geochemistry, benefitting from advances in analytical techniques, such as ICP emission spectrometry and mass spectrometry has found new insights in understanding the Earth's crust. Geophysics utilizes satellites and airborne methods to understand the planetary behaviour of Earth, and to penetrate deeper into the earth's crust. Exploration geophysics reveals oil-bearing structures and environments favourable for mineral deposits. Sophisticated chemical instruments have made incredibly accurate analyses of microsamples such as the latest ion microprobe methods (SHRIMP) and open new horizons for understanding mineral structures and aggregates in rocks. Geology, defined in the past as a historical science revealing the evolution of the earth through time, has become more and more complex due to a multi-disciplinary approach to study Earth from satellites; its inner composition through gravimetry and seismics; its mineral potential through geochemical exploration methods and interaction between atmosphere, hydrosphere, and lithosphere; through physical chemistry, biochemistry and soil stratigraphy.

Mineral resource exploration, which was the economic motivation for prospectors, mining companies and state geological surveys, is not now the only motor of scientific progress in geosciences. As Dr. Williams stated, geological surveys face many new frontiers, the most important of which arises from the growing challenge of sustainable development. It is obvious that we are facing planetary programs of land and water management, resource management, and other challenges imposed by development of the infrastructure of a highly industrialized society.

Geologic hazard prediction is new, especially in zones of high seismic activity as it has been demonstrated by Dr. Ogawa from the Geological Survey of Japan. He showed how the JGS studies the effects of earthquakes of different scales. The activities of geologists comprise detailed mapping in the earthquake-prone areas, monitoring of precursor shocks and changes of water geochemistry, historical seismology and experimental petrophysics. These geological and geophysical activities are coordinated with earthquake studies of other state agencies. Thus efficient earthquake prediction can be established and further improved through international cooperation. That cooperation is needed in all branches where a global environmental danger exists and threatens future sustainable development.

In the last two or three decades, public interest in environmental prediction and protection has grown. A century ago scientists didn't care too much about pollution caused by industrial centres. The prolonged industrial activity in certain areas had brought deforestation, and river and marine pollution of unsupportable dimensions. Sustainable development of human society requires joint efforts under peaceful conditions. Geosciences are carriers of good will and must internationalize technologies for monitoring environmental changes, earthquake and slope stability hazards, subsidence and flood hazards, and volcanic eruptions, etc.

Multi-hazard assessment documents land use constraints. The area of these constraints is mapped and included in remediation designs where greater cost savings can be realized. Dr. Ogawa showed us clearly how the GSJ performs a comprehensive analysis of earthquake risk, even for small-scale earthquakes, and makes an effort to locate them despite their very restrictive after-shock areas. Such effort to mitigate hazards should be a general task for geoscientists in the future. That is, information on

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pre-development land use planning in which the experience gained by institutions such as the geological surveys of Japan, Australia or the US will be distributed internationally. This is one of the aims of a second generation of Australian regional scale geoscience maps and databases which use a combination of powerful modern computers with well proven geologic and geophysical survey methods. Dr. Williams defines this aim as to strengthen the geoscientific information base required for sound environmental management and land use decision making.

New frontiers emerge through better understanding of the complicated rock, soil, and water interactions. Dr. Williams stressed that the knowledge of the regolith is advancing rapidly as traditional Quarternary studies are being complemented by the results of airborne measurements and surveys involving both aircraft and satellite mounted multispectrum scanners. The precise measurement of rates of natural changes as a tool is also important. Numerical dating of Quarternary deposits by modern methods will have great impact on the Quarternary and soil stratigraphy. New methods will incorporate time dimensions to create multi-dimensional models. Renewable geothermal sources of energy will become increasingly important in the planning of sustainable development. Three-dimensional insight, based on geophysical modelling of crust, will contribute to a cost-effective evaluation of suitable structures that was impossible only a short time ago.

There is insufficient time to enumerate the capacity and advantages of new sophisticated equipment and tools for geochemistry, geophysics or the rapid change in data manipulation and geological concepts. But all of us, whether old or young geologists, feel that there must be a balance between the impersonal machine-like approach to data storage and manipulation, environmental control and the interpretation efforts of experienced geoscientists. Conceptual geological thinking must always return to field evidence and rely on scientific intuition in the development of new geoscientific concepts.

The development of new geoscientific concepts plus new technologies for geosciences should be represented very comprehensively. This comprehensive presentation of data interpretations and new concepts, as stressed by Dr. Williams, must be made both for decision makers and for those affected by their decisions. These together must comprise the consensus for sustainable development.

Table 1: Some New Geoscientific Concepts/ Frontiers

In GEOCHEMISTRY	- envnviironmental concepts and monitoring systems of surface and near surface chemical changes
and	
HYDROGEOLOGY/ HYDROLOGY	- differentiated water protection policy
In GEOPHYSICS/	- geologic hazard assessment and mitigation
TECTONOPHYSICS	- geophysical modelling and deeper insight in the Earth's crust and mantle
and	-planetary approach to structural global problems as to symmetry or assymetry features of the Earth
STRUCTURAL GEOLOGY	
In EXPLORATION/	- optimizing the environment for mineralfuel exploration
MINING GEOLOGY	- providing a reliable information base for the assessment of potential mineral and fuel resources
In All GEOSCIENTIFIC	- precision of time and climate factors in geologic events and stratigraphy
BRANCHES	- intensive new work on presentation of data interpretations for decision making and public.

International Communication, Collaboration and Cooperation

D. Ross.[1]

Before I get to the specific questions of this theme, I'd like to take the opportunity of spending a couple of minutes reviewing the new responsibilities that I take up and some of the changes that have happened in New Zealand. I will do this because I think it follows on from some of the discussions we've had.

With the election of a new government in New Zealand about 18 months ago, the government initiated a major review of science within the government departments. One of the recommendations from that science task group was to take the science sectors out of the two major science departments, the Department of Scientific and Industrial Research and the Ministry of Agriculture and Fisheries, and to establish separate independent crown research institutes.

One institute that relates to the geological sciences is the Crown Institute for the Geosphere. This was established from the combination of two Divisions of the Department of Scientific and Industrial Research, the Geology and Geophysics Division, (essentially the Geological Survey of New Zealand, incorporating the geological survey activities and the geophysical programs), and the Institute of Nuclear Sciences and Engineering Seismology which were contained in the Physical Sciences Division of the Department. This new organization will be a Crown institution reporting to a Board of Directors. I have the privilege of being the new Chief Executive Officer of this institution, to be called the Institute of Geological and Nuclear Sciences. Its shareholders will be the Minister of Finance and the Minister of Research, Science and Technology, and although the organization is in some flux at the present time, the emphasis is on developing some five or six science divisions.

One of the critical things we've been looking at over the last day and a half has been the question of developing a balance between strategic and practical planning and how we communicate with the world and with our clients. That's Theme V - International Communication, Cooperation and Collaboration.

There is increasing public recognition that we live in a world that is changing, politically, and very much physically. We as a human race are affecting that change. As geoscientists we study this change, we look at earth processes that occur over a wide range of time scales. It is this knowledge that, as Professor Cordani stated, is new knowledge for the human race. This is what we must emphasize. As earth scientists we study change, we have to pass that knowledge on. We are the conduits of geological knowledge, as Dallas Peck mentioned yesterday morning. We must be pro-active in developing new ways to get our message across, and that's come through I think in all the discussions. We must get this message across to our public and to the legislatures. The quality of our work will be measured by how successful we are in this communication. So international communication\cooperation is essential in fostering this conduit of information and ensuring that our public is aware of where we are going.

Professor Cordani talked about two structures for international collaboration: government structures, which he identified with United Nations programmes; and non-government programmes represented by ICSU. Professor Cordani emphasized the symbiotic relationships between the Unions and surveys, the opportunities that this international collaboration on a large scale provides for geological correlations across boundaries, and the opportunity it provides for enhancement of expertise in particular areas of research. Effective collaboration benefits the science and it helps encourage and develop the expertise of our staffs.

Professor Cordani's talk indicated that many of our modern concepts of geoscience have resulted from major international projects. He talked about the programs

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sponsored by the international unions, in particular the International Geophysical Year, the Upper Mantle Project, and the development of plate tectonics.

I also want to refer to the opportunities for bilateral collaboration, for regional collaboration, and perhaps for continental collaboration that came out of this morning's presentations. This is becoming increasingly important in demonstrating how we develop our science and build the acceptance of our science as important to national interests.

Peter Cook this morning commented on the difficulties in dealing on a multilateral basis as opposed to a bilateral basis in terms of aid to developing countries. That's an issue that we have to address. Another important question is the role geoscientists must play in being pro-active to look at these regional problems in the appropriate fashion.

MOU between countries can provide a focus on economic interests of individual countries and an opportunity for maximizing expertise, and improving product delivery both in a timely fashion and in terms of the ultimate product. It can also improve the cost-benefit opportunities. As we look at international collaboration I think we must also look at the framework of our own more regional basis as well as at the broad global scale.

Tony Naldrett spoke about the International Geological Correlation Program (IGCP), and provided us with an excellent review of IGCP and its importance in providing for geological interpretations across political boundaries, the opportunities it provided for linkages between the developed and developing nations, and the substantial leverage that a program of this type provided for funding new research. He pointed out that a significant aspect of IGCP was that projects were initiated at the grass roots. He also identified the concerns relating to that and the problem that projects tended to be reactive rather than pro-active. So they were not targeted as priorities as such. He presented us with the challenge that we as geologists must sell this program to our masters, to our countries.

He went on to talk about how programs such as IGCP must evolve. He suggested that IGCP provided one of the mechanisms whereby we could develop new concepts and provide a proving ground for new concepts which otherwise may not be funded so effectively. He challenged us to identify projects which could demonstrate wide international support, to fulfil the scientific requirements of the program and achieve some concrete objectives within the 5-year time frame of the IGCP program. He used the example of the geochemical mapping as one where these objectives had been achieved and had led to the development of a major new thrust in mapping. The opportunity of projects like this to provide a proving ground for international initiatives is something that we, as geologists, must look at.

The question of IUGS versus the idea that has been considered here of a World Geological Survey Committee: I don't want to preempt anything that's coming up in the immediate following discussion. This was a question that was addressed to Professor Cordani. I was pleased to see that he responded very positively and identified the importance of maintaining an association of surveys that would provide qüite a different approach to collaboration of science, than the international unions do. The question that I think comes out of this, and that he answered positively, was: Is there room for both an International Union and a World Geological Surveys Committee? I would certainly support serious consideration of both. Another question is, "Is there a duplication of effort?" One of the things that we've heard during the discussions is the way in which some of the provincial, state and regional geological surveys have used committees of this type in their own countries. In the case of the African Continent, there is an effort to bring together groups of geological surveys, to discuss the coordination of geoscience policy, to look at opportunities for collaborative surveys to address more of the regional programs. Perhaps there is a model to be considered here.

CONCLUDING BUSINESS

World Geological Surveys Committee? Proposals and Discussion

D.C. Findlay

Concluding Thoughts

R.A. Price

Closing Remarks

E.A. Babcock

A World Geological Surveys Committee? A Proposal for Discussion

D.C. Findlay[1]

It seemed to me, since we put the topic of the possibility of a world organization on the table, that we have some responsibility to outline what we have in mind in this regard, and why we thought it might be a timely topic to wind up this conference.

When we began to plan this International Conference of Geological Surveys about a year ago, it seemed that there were a number of timely reasons to convene such a meeting. These included:

* a wish to impart an international flavour to our 150th anniversary celebrations;
* our recently-completed long-term strategic plan (5 - 10 years) process had identified issues such as environmental geoscience that we knew were also of concern to our sister agencies in other countries;
* we thought that it would be useful to compare the views on these geoscience issues with those of our counterpart agencies around the world;
* Finally, since many of the new challenges facing scientific institutions are increasingly global in span, it seemed useful to consider how we might ensure continuity of collaborative responses to such challenges.

This last factor led us to pose the question of a possible world organization of geological surveys.

None of these reasons is particularly new in itself. In particular, the concept of global science as in "the global laboratory" has certainly been a fundamental tenet of the earth sciences, probably since the original "Challenger Expedition". Many of us have been involved in one way or another with international scientific projects, under the auspices of IUGS (International Union of Geological Sciences), IGCP (International Geological Correlator Project), UNESCO or any one of dozens of international organizations or projects. Thus given the already extensive network of both formal and informal international linkages, the question of whether we need any additional mechanisms is a legitimate one.

Last summer we sent out letters to many of your organizations to sound out potential interest in convening this conference. At the time we also asked if there would be interest in discussing the possibility of forming a World Geological Surveys Committee or equivalent organization. Most of you responded positively, although several had some reservations about the practicability of such an organization, primarily because of the numbers that would be involved. At any rate, nearly everyone agreed that it would be worthwhile to put it on the agenda for this conference.

CONSIDERATIONS

Our view is that there are - as is usually the case - both reasons for and reasons against a world organization of geological surveys. I have summarized some of the more obvious ones here. I am sure there are probably many others that I have neglected.

On the positive side, the possibility of using such an organization to sponsor or implement major transnational projects of interest to the global geoscience community seems a genuine opportunity. In his talk yesterday, Professor Naldrett singled out IGCP Project 259 (International Geochemical Mapping) as an example of a concept that has gained widespread international support. He also noted that such large and complex projects will require the active participation of national geological surveys of equivalent organizations. This will be the case because of the magnitude of the task involved and because of the financial and manpower resources that will be needed.

IGCP 259 may, however, represent only one phase of a much larger requirement. It seems clear that nearly universal concerns about environmental degradation and the wise stewardship of land resources will move us toward the development of formal systems of impact-

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assessment mapping. In such programs, geochemistry will be only one of several data sets that will need to be considered.

A second general advantage might lie in the establishment of a formal network of communications amongst national geological surveys. Most of us are familiar with the communication advantages afforded by "networks" in a variety of situations both locally and internationally. The establishment of an international network at senior levels of Survey organizations might be useful for a variety of purposes that could contribute to the overall effectiveness of international geoscience.

On the negative side, the "cons" are also fairly obvious. All our agencies are under increasing resource constraints and, of course, the establishment of yet another organization with attendant commitments for meetings, projects and related matters would presumably add costs to the system. On the other hand, it might be argued that, in the context of the future of our planet, the costs associated with increasing our instruments for transnational collaboration and communication may be affordable indeed.

The logistics of a global organization that would presumably attempt to schedule meetings with some reasonable periodicity would obviously be unwieldy. On the other hand, this is a phenomenon common to any large organization and there are obviously well-tried ways to accomplish this.

A more serious question might be the danger of potential conflict or duplication of effort with long-established and successful international scientific organizations such as IUGS, for example. Perhaps this would come closest to the nub of the question. However, many projects conducted under the auspices of non-governmental organizations like IUGS or IGCP commonly rely heavily on local government funding for their actual implementation (either through agencies like geological surveys or through national science granting agencies). Thus perhaps there is room here for discussion of ways to better integrate the efforts of government and non-government geoscientific agencies, particularly in the delivery of large complex international projects.

Last, but probably not least, there are the questions of politics and bureaucracies. National geological surveys are components of bureaucracies and are the servants of their political masters. In the eyes of many scientists, this is held to rob them of credibility in the pursuit of objective and non-partisan scientific activities. On the other hand, politics and bureaucracies are part of the human condition and are unlikely to disappear. They come under the category of "givens".

CONCLUSIONS

At this stage it would not be appropriate for us to propose any specific recommendations concerning the feasibility or non-feasibility of a World Geological Surveys Committee or similar organization. On balance, however, it seems a reasonable question to investigate. Given sufficient interest, a result of the discussions here today could be the establishment of a representative committee or “scoping committee” to look into the question further. Over the next year there are a number of logical venues where such an exploratory committee might convene. Two of those would be at IGC (International Geological Congress) in Kyoto this August and the next sequence of UNESCO/IUGS/IGCP meetings in Paris in January - early February of 1993.

I have proposed this idea as a means to get discussions started. And now, Mr. Chairman, I'll stop there and perhaps we can let the debate begin.

Final Discussion

A. Darnley: One thought occurred to me arising from my experiences over the last four or five years of trying to advance an international geochemical project. A continuing difficulty has been the resistance of most of the existing international science promotional organizations to support data collection as distinct from research. The prestige, the priority always seems to go to process studies. And this is where scientists therefore look for the good ideas and the things that are going to get the money. But I would argue very strongly that sound systematic data is the basis of any science, and particularly in the earth sciences where we deal with so many variables. And the existing NGO organizations, I think it fair to say, do turn up their noses at any suggestion that a project is primarily aimed at data collection as distinct from coming forward with new concepts. So I would say that by having a World Geological Surveys organization which focused to a considerable extent on the need for global systematic data relating to the earth sciences, it would not necessarily be treading on the toes of the already established organizations which are much more oriented towards the promotion of new concepts and the study of processes.

M. Kürsten: Within IUGS it's good to have both surveys and university science. There is a necessary friction or tension between these two areas and we all need to stand up to this tension. So I would not see this as a reason to create a separate unit. The second comment comes from my own experience in Europe. We have the Western European Geological Surveys group. This group in itself is not homogeneous. In Germany we have provinces (lande), as you have in Canada. And it's difficult enough to combine these. So annually in Germany we have two meetings of the provincial geological surveys plus the federal institute, of which I am the head. On this basis we coordinate our activities within Germany. To represent ourselves within the European concert, overseas activities are a federal responsibility in Germany. This means that I represent the German lande (provincial) geological surveys plus the federal geological survey in this European concert. But given the jealousy of the provinces, it is necessary that one of the provincial chiefs be present at these meetings. All this works very well, but I could imagine that if you are thinking of a worldwide committee you would have added difficulties of a similar kind. If I could make a suggestion it would be that at first everywhere in the world we should try to form groups on a regional basis, continent-wide or region-wide, just as the conditions are. Once we have formed a consensus among these more regional units, then we will be able to come together represented by one of the Europeans. Within Europe, for instance, our chairmanship changes once a year, it goes from one survey to the next. Each one of us would trust the present-year chairman to represent Europe within a worldwide context. This might be a mechanism.

R. Rutland: I think the proper place to start has to be what the functions of such a body would be. You would have to say that we start from the basic assumption that our individual governments have responsibility for strategic research, and we've had some discussion about how we define that and how we define priorities. I think all of us would agree that strategic research does involve looking ahead at national needs in geoscience. The question really is how that translates into international needs.

We now have global problems and this demands global cooperation. We have to carefully define just what that is and what's going to be beneficial in global cooperation. I agree that the best cooperation we can undertake initially is probably in regional groupings. There are regional resource assessments and regional considerations of land use and environmental impacts that we might wish to make. At a symposium in Bangkok, with an amalgam of countries going across both geological boundaries and major drainage systems, there were major environmental and resources problems common to all those countries, which would greatly benefit by collaboration between geological surveys in those countries.

If we go beyond the regional groupings, there are benefits in "cross-fertilization" between groups. What sort of problems does one group have compared with another? The focus here seems to have been on major international projects, such as international geochemical maps. However, we may be asking the wrong question of international cooperation. Instead of getting our governments to commit themselves to an international program of geochemical mapping, we may get them to accept that there should be international standards which they should all adopt. There's a major role in international cooperation in looking at these problems globally. But it's going to be very difficult to persuade countries to support financially major projects and accept that they all have the same priority in major data collection exercises.

A Commission of Geological Surveys under IUGS could be a beneficial forum through which these issues could be discussed. However, there are a number of bodies already in existence, such as a Subcommission on Global Data Management and Information Systems, which already serves the data information exchange area, and could expand into the Standards activity. The Circum-Pacific Council has facilitated major international cooperation projects between geological surveys in the region, led by the U.S. Geological Survey. In the mapping area we have a Commission for a Geological Map of the World which can undertake some things. So before we progress too far, we need to carefully define what the objectives are.

C.O. Kogbe: I think that this conference has demonstrated the usefulness of having a forum where heads of surveys from different parts of the world could meet at both formal and informal levels. The International Geological Congress has grown so large that this type of intimacy is not usually established. Also, there is a need to establish at regular intervals a forum like this where heads of surveys come directly in contact with governments and decision makers at all levels and discuss their problems. The IUGS could accommodate a commission or a working group to complement its activities at this level. It would be a pity if the momentum is lost and we don't support the "pros" and transport them into reality.

U.G. Cordani: I think there is a role for an association or body - you have to decide what kind of organization you wish to have - and IUGS may help support it. It could be affiliated to IUGS. I agree with most of the pros given by Chris Findlay.

Although there are difficulties, it is appropriate to have a forum for discussion for the geological surveys, and to have this governmental body to put additional pressure on the community. Because IUGS national members are different in each country, sometimes from an academy, sometimes a Geological Society, etc., they do not have the same possibility to pressure the government. You have direct seats into the governments so you can act more effectively towards the common goal of improved geology.

Arthur Darnley's comment about the difference between how scientists think and how those from the geological surveys think is correct. Academics, scientific research councils and other organizations tend to approve projects which deal with real research and not data collection. Scientists like to interpret existing data. So data collection is a big job for existing institutions, like geological surveys or observatories. However, the geological survey in one country is interested in producing data mainly for that country although there are bilateral agreements. If we go global, we need standards, as Roye Rutland pointed out, to make complete exchange of information. Each geological survey has to provide geochemical data in its own territory, and these data have to be integrated in a global network by standardization. That needs international coordination. That could be a good objective for the organization you are looking at.

E. A. Babcock: I'm not sure that we need another group to coordinate international science, as we have many means to do that. I agree that there is a need to develop international standards. It's a very daunting task. However, if I look at the meeting we've had the last couple of days, as head of a large geological survey, I found it very useful. There are some common themes that are important to all of us. It would be useful if perhaps every two or three years, the heads of the surveys could get together in an informal environment to share their experiences in managing their surveys. We all work for governments that have their own unique way of doing things, but there are a lot of common themes and there is a lot we can learn from each other's experiences. Getting together from time to time to share some of our experiences will help us run our surveys more efficiently, admitting that each one of us operates in a unique environment.

P.J. Cook: I would agree, particularly regarding the number of bodies we already have for the coordination of international science and that there is scope for comparing common experiences in management. Although it's a little separate from the science, it's relevant to the science. I don't think it's self-evident that if there is any body to be set up that it should be under the IUGS umbrella. I would prefer to have things as simple as possible. I agree that we look at the regional aspect and use that as a building block. However, there will be on occasion the need to talk in a more general way. We can't always deal through some intermediary of a regional body. I see the regional bodies as perhaps being a coordination group in between meetings. However, the first step is to set up an informal group that would look at some of these issues and then put forward a proposal, as simple as possible. Let's have simple lines of communication.

If the body is set up and if it finally decides to not set up any world geological surveys body, then there is still merit in groups such as this meeting every few years. The BGS has its 50th anniversary in four years time, and maybe four years is an appropriate time for a group such as this to meet. There is merit in the informal interactions at these sorts of meetings. I see merit in setting up a working group to look at whether anything more is needed, but let's keep it simple.

D.L. Peck: I agree that it's been a very useful meeting, to see what troubles other geological surveys have, and what needs there are and how they're meeting them. There are too many organizations in my country and in this world, and the thought of another big fancy one appalls me. But I would like to do this again in a couple of years and we need some mechanism for doing it. So some scoping committee that might think through this might be a good idea.

R.A. Price: I sense that there is a desire to proceed with some sort of very loose and informal organization that will allow the heads of national geological surveys to communicate on common problems of the day. I also sense an interest on the part of IUGS for affiliation with this because it gives them an important communication channel, which may also be important to the heads of the geological surveys. Recognizing the initiative that has been taken here by Chris and his colleagues in putting this together, I wonder if it wouldn't be appropriate to leave it completely informal and leave it to Chris to consult with some of you during the remainder of your stay here, and see how to proceed with this.

D.C. Findlay: That's fine with me. I saw my role to put the question on the table, to listen to the response to it. It works out to be just about a hung jury, with a couple of people saying "yes, but no". Peter placed himself very neatly on that fence, that he agreed with people who said we didn't need another formal organization, but it might be useful to have a few people look into something that could or could not happen in the future. So we'll try and talk to some people.

R. Rutland: Regarding the BMR 50-year celebration, Neil Williams and I had already been discussing that we would like to invite heads of geological surveys to that occasion. Irrespective of whether such an organization is set up, it will be an occasion where we would want heads of geological surveys from around the world to join us. If I may have been seen to be one of those on the fence, I suppose I was emphasizing that we need good reasons and we need to be sure that we're going to achieve something with such a body. What I would like to emphasize is being more positive about getting the regional associations going. Let's get some positive conclusion from this meeting that we will all go away and support our respective regional organizations much more strongly.

R.A. Price: I think I recognize in the discussion about regional and international organizations a large-scale version of the situation of state or provincial versus national organizations, that most of you belong to two constituencies on the international scene, just as you do on the national scene.

Concluding Thoughts

R.A. Price[1]

I'd like to make a few concluding comments about new challenges, new opportunities and the way we operate.

I think the challenges are obvious. A burgeoning human population, growing demand for resources, and a need to develop those resources in such a way as to minimize environmental impacts. A few buzzword phrases encapsulate the whole situation: resources for the future but sustainable development of those resources. There is also growing concern about public safety and security. I was deeply impressed about the description of the situation in Tokyo and it made me think about the consequences under present circumstances, of a disastrous earthquake on the scale of the one in the mid-1920's. That earthquake was a disaster in Japan. In the modern world, it would be a global disaster, because it would disrupt the economic and social fabric of the entire world.

That brings me to the question of opportunities. Many of the problems we now face are global problems and they will require global cooperation and coordination. In some way or other, this cooperation and coordination will have to be achieved. In the remainder of this morning's session, we will have the opportunity to address this emerging need and so I'll not discuss the matter here. The other opportunity I want to mention is the availability of many new technologies, not the least of which are technologies for high speed data manipulation, analysis, and display.

I will conclude with a few comments on the way we operate: there has been a lot of emphasis on operating a geological survey as a business, a good business. The first question I ask is, "Who are your customers?" and "How much are your customers prepared to pay for your products?" Presumably the products are geological information and advice and the customers are people who will be prepared to pay you for them because they can't get a better product at a better price from someone else. I suggest that for national geological surveys the customers are the people of the nation, who act through the governments of the nation. I suggest that if we want to be forward-looking, we must not simply respond to the presently identified demands of those customers. Instead like good businessmen, whether selling fast foods, cars, computers or communication devices, we must look forward and identify emerging needs on the part of our customers (our people and our governments) help them to see their future needs, and help them to meet their future needs. This is a leadership challenge. I think it's a leadership challenge for every individual geological survey and, collectively, for all the geological surveys of the world.

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Closing Remarks

E.A.Babcock[1]

Thank you very much for coming. To me, the importance of this meeting was simply that it happened. This has been a unique chance for the heads of surveys to talk about common issues and problems and I believe it has provided value because of that.

I've seen some common themes coming out of these discussions and I'd like to comment briefly about them.

One theme is that of resource constraints which is affecting many of our organizations. Other common themes are: the need to better inform our political masters and the public about the value of our activities; the widely growing interest in environmental studies and hazard studies; and the need to work collaboratively within our science as well as outside, in cooperation with other disciplines.

I see great strengths within our geoscience organizations but I see weaknesses as well. To explain this I have to tell you a bit about myself because I have a unique perspective on geological surveys. I started out as an academic geologist teaching at a major Canadian university and then was head of a small provincial geological survey. After that, I completely left earth sciences and managed industrial research as a general manager. Now I've come back, I have rejoined the earth sciences. I've seen them from the inside as a junior academician and I've seen the geosciences from the outside. Now I'm back within the earth sciences community.

I think that my boss, the Deputy Minister, is right. The earth science community is like a club or a religion. He refers to us at the GSC as the Jesuits. Here today we have people from all over the world and we all speak the same language, the language of science. That is our tremendous strength. But it's also a weakness and it could be a terminal weakness for geological surveys. I believe many geological surveys are at a crossroads. If we go down one path we're going to see success and flourish, and our science will be recognized for its future importance in the world's sustainable development. The other path I see is one of decline, probably a gradual decline, a diminution of resources for our science. Eventually geological surveys following the second path, if they survive, will not be particularly important. Success lies in the direction of supporting sustainable resource development in an environmentally responsible way and also contributing to the solution of environmental problems. The road to decline will be characterized by a failure to respond to the environmental imperative and an adherence to a classical approach to geological mapping and research. So one of the questions I have to pose to the group is: "If we're so useful and if our science is so valuable, why aren't we better funded?"

That is one of the themes related to resource constraints. Whether we're talking about large national surveys, such as the British survey, the GSC, the US Geological Survey or whether we're talking about smaller surveys such as those in Africa or the state and provincial surveys in the US and Canada, we're all under similar constraints.

There are global reasons for these constraints such as the world recession, but I think there is more to it than that. We have to do more - and Peter Cook raised this point - to make our political masters aware of the fact that we support economic development. He also raised the very important point that we have to maintain core support for our activities. The pendulum in Canada is shifting towards the side of pure economics, pure support for industrial development and away from the side of public good. We must maintain a balance so that we can continue our public good role. We have to be better salespersons (although I hate to use the word) in order to better inform people and politicians about the value to our societies of what we do. Dr. Berbert made the last point very well.

In Canada as well, we must do a better job of convincing the people who deal with science policy at a national level that the industries that we support are high technology industries. At the moment, the feeling at some senior levels is that the future of Canada is in high technology businesses. Yet resources are what pay the bills. I'm sure this is true in other countries too. We have to make sure that decision-makers are aware that

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resource industries are high technology industries and from these bases we can build even more high technology.

The environmental theme came out strongly in many of the talks (Dallas Peck, Dr. Johan, Ogawa, Berbert, Kogbe). I suspect that if we put our long-distance glasses on, we will see that increasingly the environment will be a dominant theme for geological surveys. That doesn't mean we will abandon the natural resource industries, but sustainable development will push us in the direction of environmental studies.

This leads us back to the theme of being more outwardly focused. We have the strength of our science but we've got to get out and learn to work more with other disciplines. I cannot think of a single environmental issue that doesn't involve the earth sciences, whether it is acid rain or waste disposal. Yet departments of the environments and environmental groups don't very often think about us and our science. We've got to do a better job of making sure that our contributions are made and that we are heard and that we are in there contributing to the solution of environmental problems. Otherwise I think we're going to go down the path of slow decline. I don't think that would be good for geological surveys, and it would not be good for our countries nor good for mankind in general.

I found the talks on resources by Kursten and Czichos to be particularly interesting. The message that came to me is that globalization of markets (that's not new) and the decline of prices of commodities are pushing us to the development of world class deposits. One can see that happening in Canada. Our energy industry is "imploding" - it's simply going elsewhere, going "elephant hunting" in other parts of the world where there are bigger fields to be found. The same thing is happening with the mining industry. It's not imploding - the industry is picking the ripe fruits in other parts of the world where known world-class deposits exist, and which can be brought into production more quickly and perhaps more cheaply than here.

The need to explore for world class deposits points us towards the issue of technology. I found Neil Williams' talk about the Australian experience interesting. The Australians are combining traditional field mapping and some technologies that are new and some that are established, such as remote sensing, radiometrics, and aeromagnetics, to look deeper. Certainly, in many parts of the world the easy-to-find deposits have been found and we're going to have to be looking for these big world-class deposits at greater depths. That's going to provide a challenge for us to develop new exploration technologies, intellectual technologies and also technologies in the classic sense.

From the sessions on provincial and state surveys it's quite apparent that there is an important continuing role for these organizations. They're smaller than the national surveys, but because of that they're more agile and they're much more closely linked to the development of local industry. They're niche players, with a different niche from that of the larger national surveys. They're particularly important in countries such as Australia and Canada where the states actually control the resources within their boundaries. Each one of these smaller surveys then takes on a flavour unique to the needs of the state. One can really see that in the USA where they range from large surveys such as Illinois down to one-person operations housed at university in some of the New England states. Once again funding remains a problem. It means that state surveys must also sell themselves and the relevance of what they do to their political masters.

The talks on non-governmental collaboration by Cordani and Naldrett point out the value of having overarching infrastructure organizations, such as IUGS for the promotion of international cooperation, particularly as geosciences become more global. Non Government Organizations are particularly valuable in linking scientists in the less industrialized countries to the world scientific community. They have been able to achieve great things with very minimal budgets, but here also, funding remains an issue. We who are in charge of geological surveys in industrialized countries should give more thought on how to keep these organizations viable.

In dealing with the issues facing surveys, in various regions the challenges are unique to the region. Many African nations face a real challenges to revitalize their geological surveys. That's going to require some help from other regions and I'm sure it is also going to require a lot of effort from the African countries themselves. I believe that political stability is going to have to take place before some of these surveys will be able to achieve the potential they should be operating at. I'm not sure if it would succeed, but I thought Dr. Kogbe's idea of developing regional geological centres of excellence was very creative. China faces different challenges: a huge geoscience organization, a huge country undergoing rapid development and a country very active in building scientific links to other countries. The GSC has many links to China. In fact, if we were to let it happen we could probably spend all of our resources interacting with China. Our capacity to interact with the Chinese geoscience community is relatively small in comparison with their capacity to interact with us.

I was struck, not necessarily in a positive way, by Latin American attendance at this meeting. It probably is the result of a variety of causes: the nature of the organizations there and the shortage of money. However, given the importance of mineral resources in Latin America, I think we need to bring Latin American countries into this fold of geological surveys.

The talk by Carlssen on client focus relates to something we at the GSC are doing; that is, building links with our clients. We're taking a total quality management approach to it. Total quality management is a bit of a fad but it's good stuff, and it works. If we don't know who our clients are and we're not working with them, then we're science- or technology-push rather than client-pull. A market or client pull approach to our science is required for the long-term success of our surveys.

I found this to be a very useful meeting, very interesting, but difficult to summarize. Some common themes are the need for collaboration with our clients as well as other science disciplines, the growing importance of environmental studies, and a need for geologists to be better communicators, both at the political level and the level of the public.

Dr. Riddihough ended by proposing a vote of thanks to all those who contributed to the success of the conference.

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