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The Changing Landscape of Earth Sciences in Canada: A Story of Erosion and Uplift

GAC Presidential Address, Annual Meeting, Quebec City Quebec, 18 May 1998

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The Changing Landscape of Earth Sciences in Canada: A Story of Erosion and Uplift

GAC Presidential Address, Annual Meeting, Quebec City, Quebec, 18 May 1998
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INTRODUCTION

The occasion of a Presidential Address is one of those rare opportunities for an earth scientist to address a broad cross-section of the Canadian earth science community. Therefore, choice of topic is critical. I toyed with the notion of a scientific talk but decided that the intricacies of conodont anatomy or biostratigraphy might be of limited appeal. I am not a geomorphologist, but I would like to use landscape as an allegory for the erosion of geosciences in Canada over the past decade and for some of the uplifting experiences that have resulted from this erosion. The landscape I am going to deal with is the landscape of our profession and its institutions. I will examine the current state of earth sciences in Canada by looking at trends for a variety of indicators over the last decade. I will deal with aspects of the private sector, including the mining, energy and environment industries, the government sector, and academe. I will demonstrate that there has been considerable erosion but also that there have been some uplifting developments and that there can be more uplift if we all heave together.

It seems to me that science, as a whole, has slipped off the Canadian political landscape. The burdens of government debt and deficit and the desire for economic growth have so preoccupied our society and our governments that little attention has been paid to other responsibilities. Many social areas have been adversely affected, even the essentials of education and health. Science has been caught in the same pattern of erosion and change.

EARTH SCIENCE'S PROFILE IN CANADA AND THE NEW ECONOMY

Within the realm of science itself, earth science has a low profile. It is not considered in the same league as physics, chemistry and biology. Further, there is a tendency to regard some of the industries in which earth scientists work, as yesterday's industries. Some economists and industry commentators (see *e.g.*, Beck, 1995) write about the new and old economy. The new economy is seen as part of the "information age" or as key components of the "knowledge industry." The new economy (Fig. 1) comprises such things as hardware and software, business services, pharmaceuticals, entertainment, communications and pipelines. These are regarded as clean and knowledge intensive, requiring people with high skills. Then, according to these pundits, there is the old economy (Fig. 1) that includes mining, oil and gas, paper and forest products, steel, building materials, and food processing: industries related to primary resources and needs. These are seen as relatively dirty, old-fashioned industries that are just chugging along. While the rate of growth may be higher in the new economy, the so-called old economy contains the things people *really* need. There are no pipelines without a supply of oil and gas. There are no electronic communications without the materials to build the latest communications devices. And goodness knows we don't need the business services that have inflicted on us every management fad known to man over the last decade: making most of us wonder whether the workplace will ever be pleasurable again.

This notion that the resource industries are static and old fashioned has pervaded the public mind set. Decision makers' heads are suffused with visions of the new, clean information and knowledge age and make decisions accordingly.

CANADIANS' INTEREST IN SCIENCE

There is no doubt that Canadians are interested in science and that they are slowly becoming more scientifically literate, as shown by two studies of science literacy, one conducted in 1989 (Einseidel, 1990) and The National Science Literacy Survey, 1995. But, at the same time, they are also becoming more suspicious of its overall benefits. On the question of trust in scientists and the efficacy of science, a comparison of the two surveys of science literacy shows increasing levels of

NEW ECONOMY	OLD ECONOMY
Hardware & Software	Mining
Business Services	Oil & Gas Producers
Pharmaceutical	Oil & Gas Services
Entertainment	Paper & Forest Products
Investment Companies	Steel
Communications	Building Materials
Transportation	Breweries
Environmental Services	Distilleries
Pipelines	Food Processing

Figure 1 Partial list of old and new economy industries from Beck, 1996.

mistrust. This is demonstrated by greater support for the notion that researchers have power that makes them dangerous (41% of Canadians in 1989, 46% in 1995). Fewer people now support the idea that jobs have been created by science and technology (52% in 1989, 45% in 1995). People are fed up with the rate of change and attribute some of it to science and technology. The public apparently is starting to regard science as being at least partly responsible for some of the bad things happening to them, especially pollution, job loss, and the overall pace of change.

Relative ignorance of earth science starts at the level of kindergarten and is perpetuated by an education system that includes only low levels of geoscience in its curricula. The typical high school graduate has only a few courses in science anyway, and these are much more likely to be in the mathematical sciences or physics, chemistry and biology rather than earth science. How can a high school graduate, who is only dimly aware of earth science, be expected to understand earth science or its contribution to our society? Little wonder that earth scientists have a low profile in the public mind.

CANADA'S PLACE IN SCIENCE

Before we take an excursion through the landscape of geoscience in Canada, let us consider the position of Canada in the global landscape of scientific research. A recent look at some of the key aspects of scientific research in Canada has been provided by Wolfe and Salter (1997). As in so many other spheres, Canada is squarely in the middle of the road with respect to many global measurements of research and development. Canada has 4.5 research scientists and engineers per thousand people in the labor force: less than Japan, the United States, France and Germany and more than the United Kingdom, South Korea and Italy (Fig. 2). In terms of the number of doctoral degrees granted, Canada has less than half as many as Germany, France and the United Kingdom, less than the United States and more than Japan, South Korea, Italy or China (Fig. 3).

In terms of research and development expenditures per capita in the higher education sphere, Canada is somewhat lower than the middle of the pack (Fig. 4). In terms of source of research dollars in Canada, the federal government is a principal funder of scientific research in the higher education sector (Fig. 5). Additional funds are provided by the higher education sector itself, provincial governments, business, private non-profit organizations, and foreign funders. Our government complains that in other industrialized economies, the private sector takes a greater share of the load.

Earth scientists work in many areas of the Canadian economy. In the industrial sphere, earth scientists work prominently in the areas of minerals, energy and the environment. In the government sphere, earth scientists work mainly within geological surveys or elsewhere within departments of natural resources, mines and energy. In the academic sphere, earth scientists populate the university departments of geology, geophysics, geography, and earth, ocean and atmospheric sciences. Let us look at each of these spheres in turn.

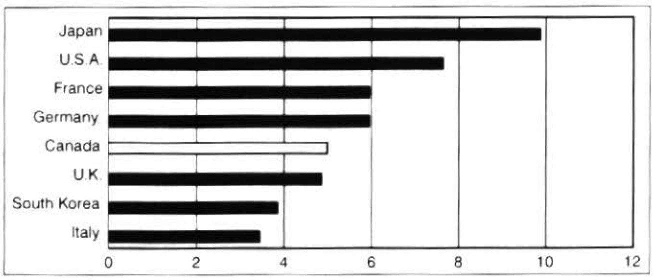

Figure 2 Research scientists and engineers per thousand people in the labor force, 1993. Source: OECD cited in Natural Science and Engineering Research Council of Canada, 1997, Report entitled *Highly Qualified Personnel*, p. 41.

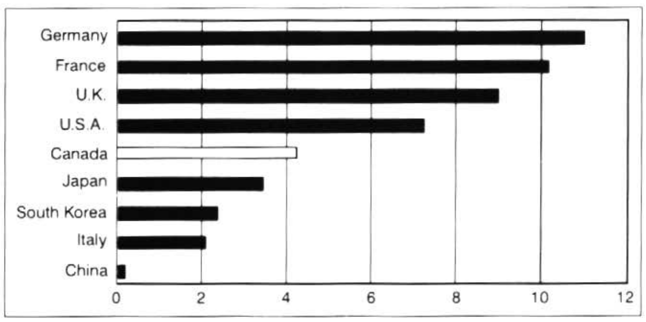

Figure 3 Doctoral degrees granted per 100,000 population, 1992. Sources: National Science Foundation, OECD, UNESCO cited in Natural Science and Engineering Research Council of Canada, 1997, Report entitled *Highly Qualified Personnel*, p. 40.

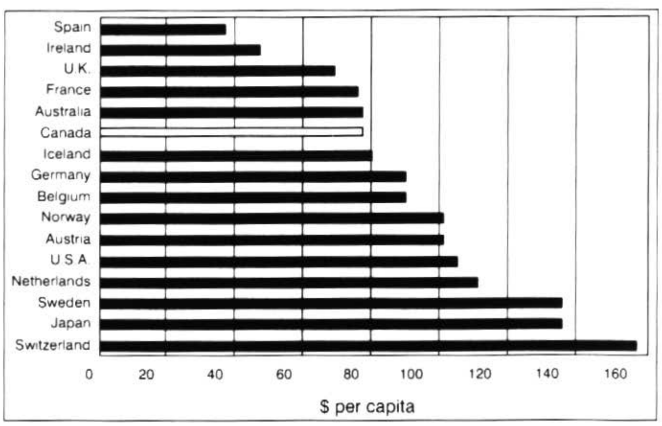

Figure 4 Research and development expenditures per capita by a selection of OECD countries. Source: OECD, STIU Database, May 1997, cited in Wolfe and Salter, 1997, Table 11. Figures for 1995, except 1994 for Australia, Netherlands and Switzerland and 1993 for Austria, Belgium and Sweden.

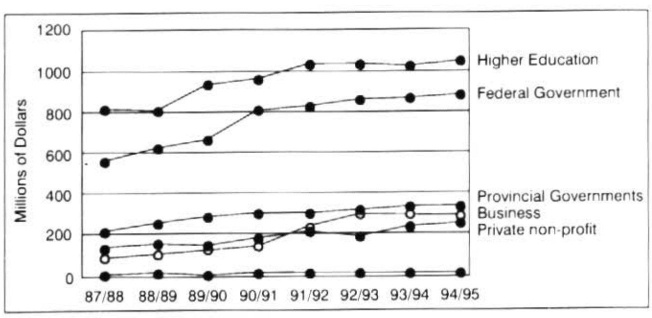

Figure 5 Estimates of research and development expenditures in the higher education sector by source of funds. Source: Statistics Canada, Table 2, Estimation of Research and Development Expenditures in the Higher Education Sector, 1994-95, Service Bulletin Science Statistics, ST 96-07, cited in Wolfe and Salter, 1997, Table 10.

THE MINERAL INDUSTRY

The mineral industry presently is not experiencing the most buoyant of times. If we review the prices of metals over the past decade, we find that the value of precious metals like gold and platinum have fallen considerably between 1987 and 1997 (Fig. 6). Nickel and tin have fared little better (Fig. 6). Equally, there have been considerable fluctuations in the prices of aluminum, copper, lead and zinc (Fig. 6). None of these trends has assisted the mining industry in Canada, although there are some brights spots, like cobalt, for which prices have risen over the last decade (Fig. 7). Other challenges face the resource industries: first, the Bre-X fiasco has seriously affected the ability to raise money among the juniors of the mining industry. Ironically, it probably did our profession some good by bringing it into the spotlight, as there were several articles in newspapers at the time about what a geologist does for a living. A second and formidable challenge is presented by native land claims that cast doubt on areas available for exploration. In addition, in some jurisdictions there are increasingly stringent environmental regulations that can increase the cost of exploration and exploitation. One result is that the Canadian mining industry has begun to look outside Canada for future prospects, but the large size of new discoveries in Canada, like the Voisey's Bay deposit in Labrador, suggests that settling land claims and dealing responsibly with the environment are in the best interests of everyone involved.

Not surprisingly, trends in the pattern of employment in the mineral industry over the past decade show a steady decline in both non-fuel and fuel mining, such that the total number of jobs has been eroded by more than 20% (Fig. 8).

In terms of research and development in Canada, the resource industries spend relatively little when compared with other industries (Fig. 9). Telecommunications lead the way in spending, followed by transportation, computer software and hardware, and electronics. Research and development spend-

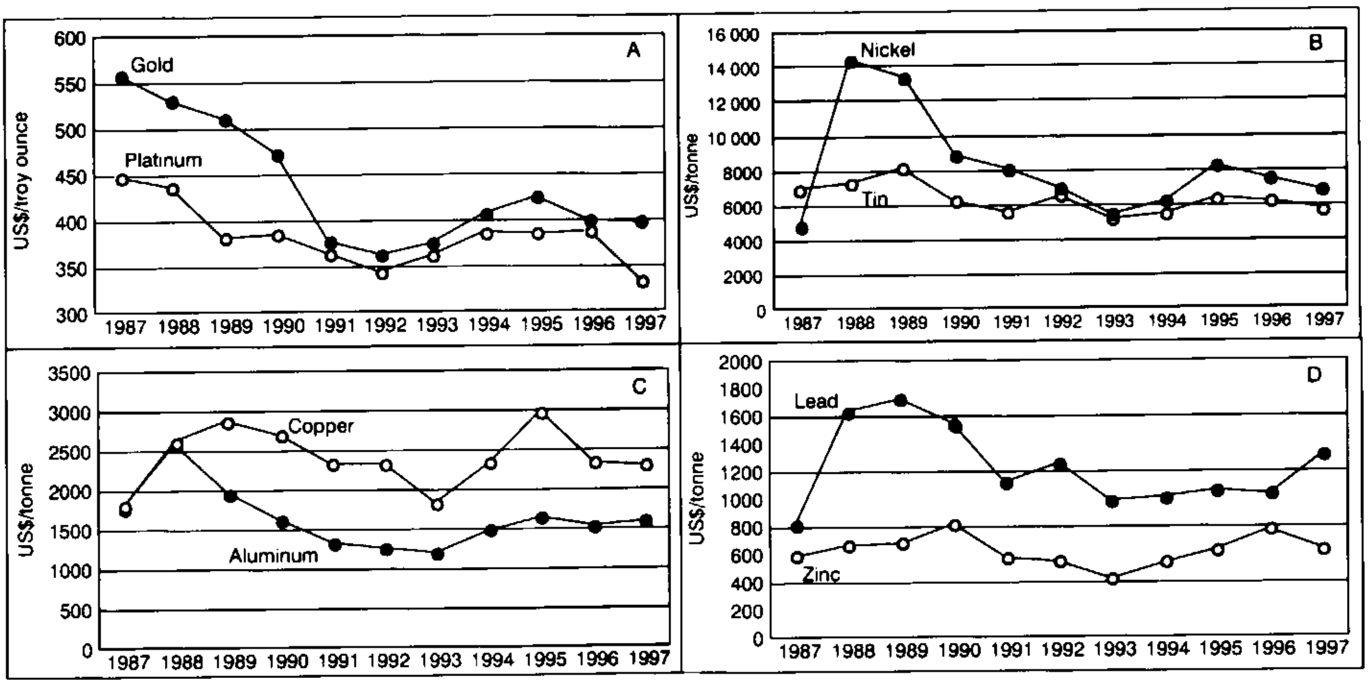

Figure 6 Metal prices 1987-1997. Source for 1987-1996: Metal Bulletin cited in Canadian Mines Handbook 1997-98, Southam Magazine and Information Group. Source for 1997: Metal Bulletin, 15 January 1998. A, prices for gold and platinum; B, prices for nickel and tin; C, prices for aluminum and copper; D, prices for lead and zinc.

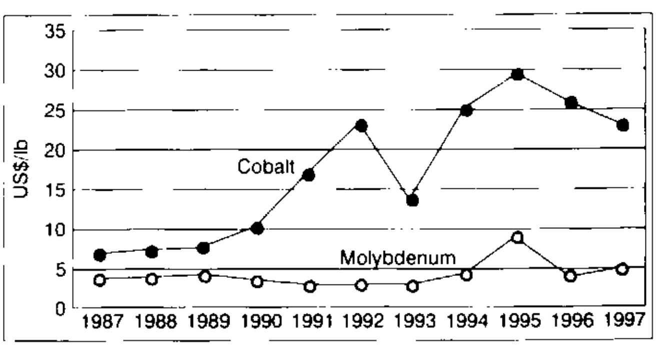

Figure 7 Prices for cobalt and molybdenum 1987-1997. Source for 1987-1996: Metal Bulletin cited in Canadian Mines Handbook 1997-98, Southam Magazine and Information Group. Source for 1997: Metal Bulletin, 15 January 1998.

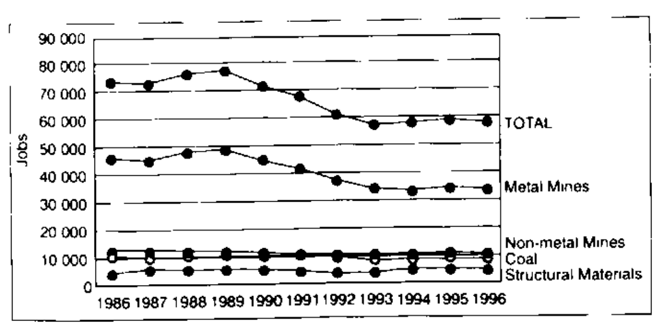

Figure 8 Employment in the mineral industry in Canada 1986-1996. Source: Natural Resources Canada; Statistics Canada from data cited in Canadian Minerals Yearbook, 1996, Table 28.

ing on pharmaceuticals is climbing extremely rapidly, presumably thanks to patent protection legislation introduced a few years ago. Finally, at the lower end are research and development expenditures on mining, chemicals, oil and gas, and forestry. The gap has existed for the entire decade and is widening. For industries that contribute so much to the gross domestic product of Canada, it is surprising how little is spent on research and development.

THE OIL AND GAS INDUSTRY

Prices of oil and gas over the last decade have fluctuated with normal cyclicity (Fig. 10). The price of a barrel of West Texas Intermediate Crude, that universal indicator of the health of the oil industry, has fluctuated over the last decade but is currently at a low level (US$14.83 at time of writing). In western Canada (Fig. 10), the price of oil used to be much higher in the middle 1980s than it is now, but has been relatively stable over the last decade. It, too, has recently gone down in concert with the price of oil worldwide. Similarly, the price of natural gas is lower now, but it has been relatively stable. Both industries have been profitable over the decade.

As in the mining industry, overall employment in the energy industries has been declining, but there have been greater fluctuations, such that 1997 levels were not much lower than they were at the beginning of the decade (Fig. 11). Nevertheless, job losses have been severe and despite recent hiring trends, the prognosis is probably not good, based on the declining prices of oil. Erosion may continue. A bright light is the future of the oil sands. Improvements in recovery methods mean that the truly vast reserves contained in them are now economic.

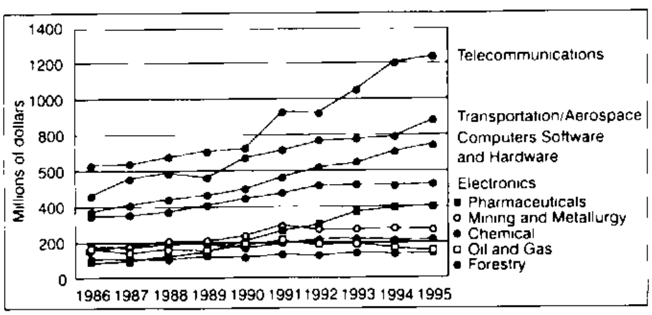

Figure 9 Industrial intramural research and development expenditures, 1986-1995. Source: Statistics Canada cited in Natural Science and Engineering Research Council of Canada, 1997, report entitled *Highly Qualified Personnel*, p. 78.

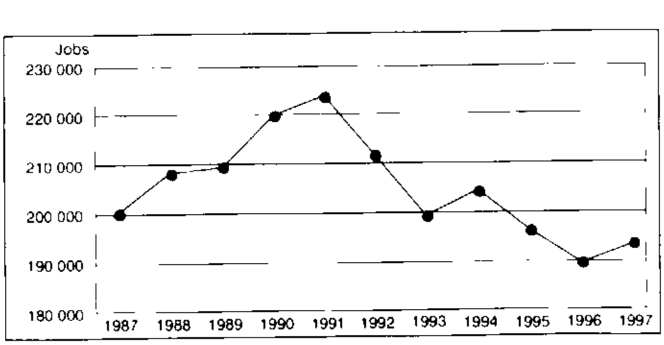

Figure 11 Employment in the Energy Industries 1987-1997. Source: NRCan and Statistics Canada, Energy Statistics Handbook, March 1998, p. 1.23 for 1990-1997; data for 1987-1989 supplied by R. St-Jean, NRCan.

THE ENVIRONMENTAL INDUSTRY

All the resource industries encounter environmental questions and must deal with environmental regulations. And, of course, the environmental industry employs earth scientists. When environmental issues became a high priority about 20 years ago, there was optimism in our profession that whole new areas would be opened up for employment and that there would be new applications of geoscience to the environmental problems that confront us.

Clear statistics are not available for employment in the environment industry but attempts are now being made by The Canadian Council for Human Resources in the Environment Industry (CCHREI), which has conducted studies on employment in the industry. According to their research, 12% of environmental practitioners are earth scientists. They conducted a survey of 1000 environmental practitioners, including people from environmental and engineering consulting firms, various companies that hire environmental specialists (like natural resource companies), and government agencies. Their studies, and those conducted by Statistics Canada, allow for a conservative estimate of about 100,000 people employed in the environment industry today. Therefore we can conclude that as many as 12,000 earth scientists currently do environmental work in Canada.

Another of the ongoing CCHREI studies extracts details from all jobs advertised in the environment industry: they have analysed 1400 advertisements over the last 3 years, of which 5% are geoscience specific and a further 25% are not specific as to the background required for the job. Clearly, there are opportunities for earth scientists in the environmental field. This, therefore, can be considered an area of uplift. Certainly many hydrogeologists and soil scientists can be counted among the work force, but much of the key responsibility still lies in the hands of those trained as engineers.

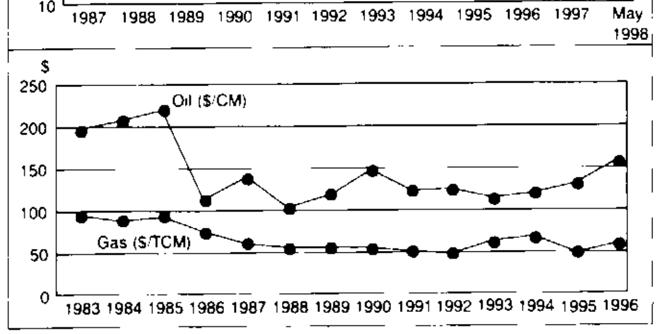

Figure 10 Energy prices. **Top**: price of West Texas Intermediate Crude Oil, 1987-1997; 1998 price is current for May, but not comparable to the other figures, which are yearly averages. **Bottom**: Western Canada oil and gas prices 1983-1996, oil in dollars per cubic metres and gas in dollars per thousand cubic metres. Source: Canadian Association of Petroleum Producers (CAPP) Statistical Handbook, September 1997.

THE GOVERNMENT SECTOR

Perhaps the greatest level of erosion in the geosciences in the past decade has been the erosion of government expenditures on geoscience. Determined efforts by governments to eliminate deficits and public debt have resulted in a vastly different landscape for government geoscience. Governments in Canada historically have provided fundamental geoscience information in the form of maps and surveys. Government science is regarded as the objective foundation upon which other geoscience, especially industrial exploration, is carried out. The knowledge base produced by government earth scientists is used not only by the mineral and energy industries as a basis for exploration but also for land-use planning, health and safety issues, hazard prediction, and environmental issues. In order to be useful it must be continually upgraded.

Natural Resources Canada is the main federal department in which geoscience is conducted. Funding for the geoscience part of NRCan and former Energy, Mines and Resources has dropped staggeringly in the last decade (Fig. 12). Funding is in three main parts: operating, capital and transfers. Operating expenditures serve to maintain the basic elements and capital provides for capital expenditures. Transfers cover a variety of expenditures, but in this chart (Fig. 12) they are mainly things like the Hibernia project and the Lloydminster upgrader. These funds flow through to the ultimate industrial recipient without touching down in the Department. Analysis shows that operating funds have declined by about 10% over the decade (Fig. 12). During the last decade, research and development funding for Natural Resources Canada has varied between 10% and 12% of total federal research and development expenditures.

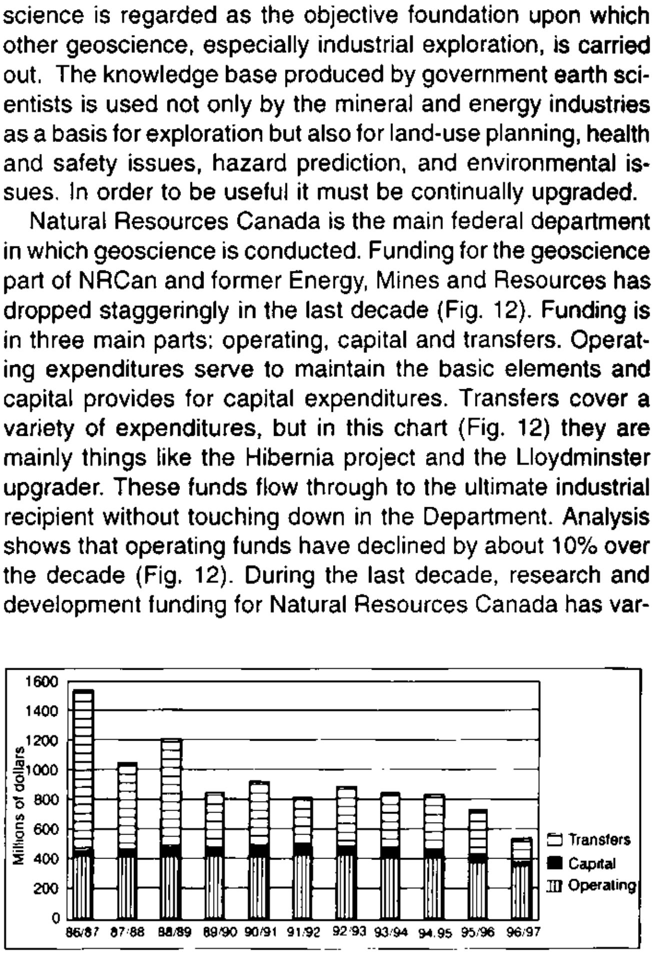

Figure 12 Total expenditures of the Department of Energy Mines and Resources (1988-1989 to 1993-1994) and Natural Resources Canada (minus forestry) (1994-1995 to 1997-1998). Sources: Annual Reports for the Department of Energy Mines and Resources and Natural Resources Canada.

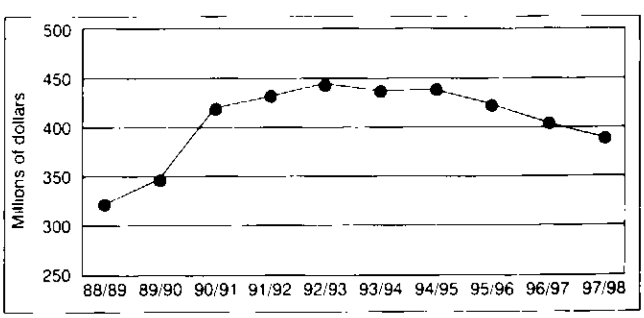

Figure 14 Expenditures on research and development by the Natural Sciences and Engineering Research Council of Canada (NSERC) 1988-1989 to 1997-1998. Source: Statistics Canada, Table 6, Federal Government Expenditures on Scientific Activities, 1997-98, Service Bulletin Science Statistics, v. 21, n. 4, cited in Wolfe and Salter, 1997, Table 7.

The amount spent on the Geological Survey of Canada (GSC) has been declining at a much more rapid rate than that shown for the overall operating budget (Fig. 13). Funding for the GSC has been reduced by more than 40%. When both GSC and provincial geological surveys are measured over the last decade, the rate of reduction is similar in both, rating about 40% in current dollars, but closer to 50% if 1986 constant dollars are used to take inflation into account. Thus the landscape portrayed is a steep downward slope: erosion is well advanced and the road ahead is of uncertain quality.

ACADEME

The third major sector is academe. This is the area responsible for the training of new earth scientists and for the conduct of much of the fundamental research in geoscience. Some clear cutting in the groves of academe is leading to serious erosion in this area as well. NSERC expenditures, which rose during the early part of the last decade, peaked in 1992 and have declined ever since (Fig. 14). Many universities have suffered serious cuts to their operating budget, thanks to reduction in transfer payments from the federal governments and provincial cutbacks. Some departments of geology have been closed altogether (*e.g.*, University of Montreal). In academe, earth science has never been a big winner, as a chart for the average grant of new grantees shows (Fig. 15). Although the

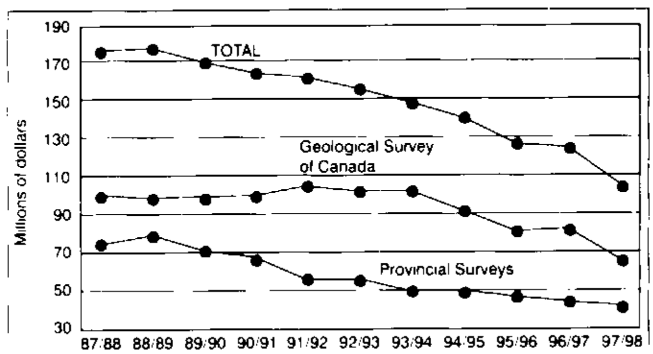

Figure 13 Geological Survey Expenditures 1987-1997. Source: Provincial Geologists Journal 1997, v. 15.

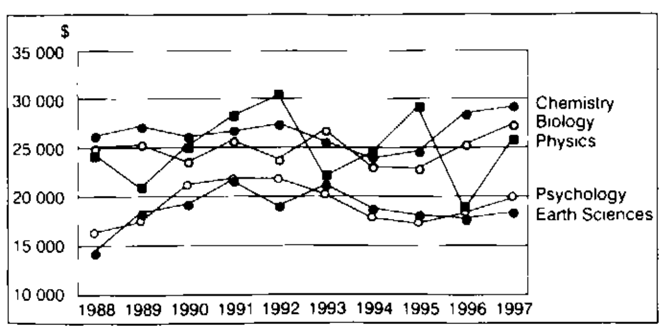

Figure 15 Average grant of new grantees, Natural Sciences and Engineering Research Council of Canada (NSERC), 1988-1997, by discipline. Source: Natural Sciences and Engineering Research Council of Canada (NSERC), *Research Grants Program Discipline Dynamics*, report prepared by the Policy and International Relations Division of the Natural Sciences and Engineering Research Council of Canada, October 1997, p. 74.

amount of average new grants for earth sciences has increased over time, the size of the average grant has always been low with respect to that of other scientific disciplines. Earth science more or less keeps pace with psychology but is significantly less than grants for physics, chemistry and biology.

In terms of the training of new earth scientists, one can examine the pattern of degrees granted (Fig. 16). For Bachelor's degrees, high numbers of biologists and engineers have been produced over the last decade, followed by psychology and computer science at about half that level. Finally, at the bottom is a cluster of physics, chemistry and earth science, which, if we look at this cluster more closely (Fig. 16), shows a curve for earth sciences that probably reflects the fluctuations in the main employing industries. However, these two cycles are almost always out of phase, such that gluts of earth scientists are available just as the downturn in the job market starts.

Similarly with doctoral degrees, the numbers are high for engineering and biology, followed by chemistry at about half that level (Fig. 16). The cluster at the bottom includes physics, psychology, earth science, and computer science. When we look at this more closely (Fig. 16), we can see a steady increase in doctoral degrees in all the sciences over the decade. So we are training more highly qualified personnel but we are probably only keeping up with the growth in population.

An optimistic note for those currently engaged in graduate work is that the demand for earth science faculty is reasonably high, as shown in a graph of faculty demand/supply index in Canada (Fig. 17). Earth scientists will be in demand over the next 5 years for faculty positions. On this uplifting note, let us move now to look at some uplifting results that have taken place in these erosive times.

CAUSE FOR UPLIFT

It is ironic that erosion often produces objects of great beauty that are uplifting to behold. One of the great uplifting experiences of this decade of erosion has been the increased need for all sectors — industry, government and academe — to work more closely together to make the best possible use of dwindling resources. In the area where the greatest erosion has occurred, the level of co-operation is greatest. It is probably safe to say that relationships between federal and provincial surveys have never been better. Work is now planned jointly, and major new projects are not undertaken without widespread agreement and planning. In most cases now, industry and academe are consulted on the development of any significant new projects. The net result is that projects are better planned, take advantage of all possible sources of data and all available expertise, and use a diversity of funding sources. Much more time is spent on planning projects and measuring their success than in the past.

Another uplifting aspect is the desire to look beyond the traditional boundaries of our discipline for new synergy. The emergence of earth system science as a more holistic view of earth processes has already made a difference and will continue to do so as research based on earth, ocean and atmosphere become better linked. The adoption of earth system science is shown by the emergence of new university departments of earth, ocean and atmospheric science. In many cases, these new departments are larger and therefore less likely to be eliminated as some have been in the recent past. We are finally emerging from a long period of specialization. We have to spread the word on this new dynamism in our science. The Association has adopted earth system science as part of its plan for the future (Geological Association of

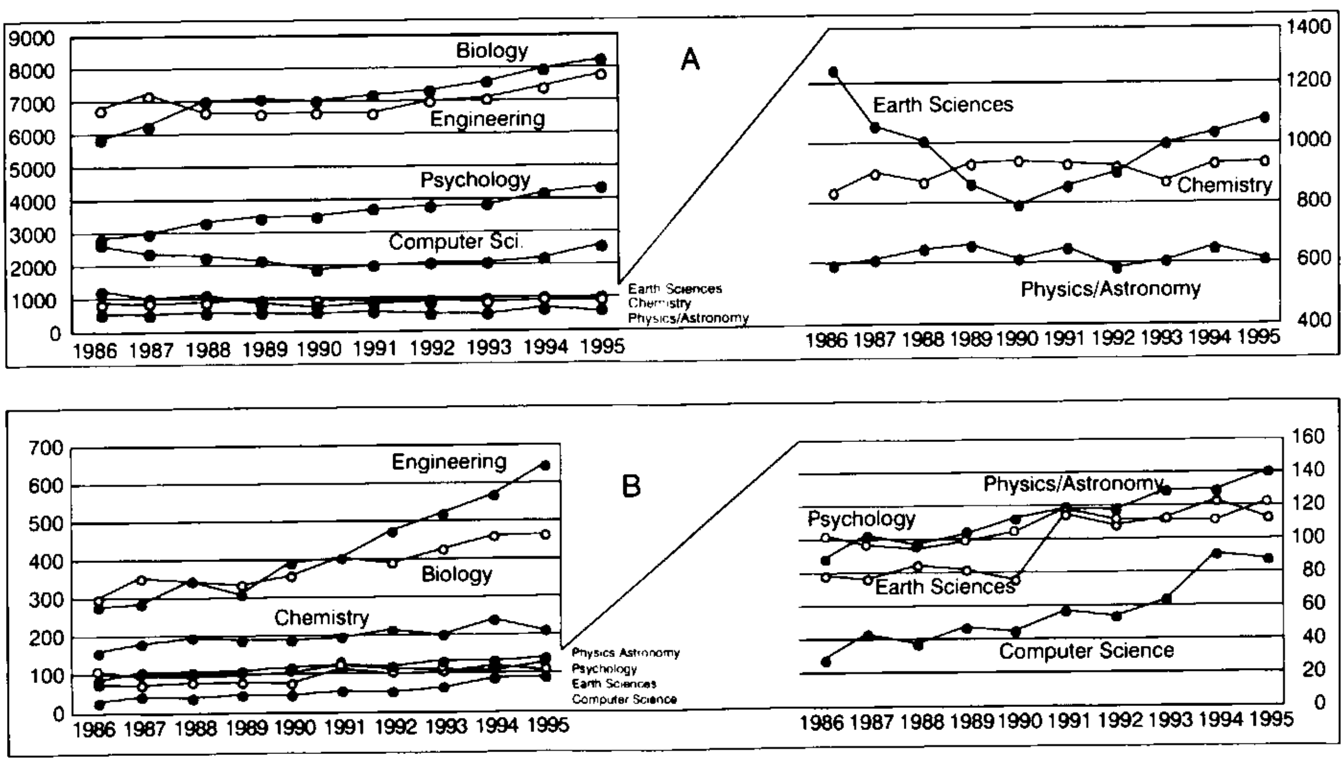

Figure 16 Numbers of degrees granted in Canada by discipline, 1986-1995. **A**: Bachelor's degrees; right half represents the detail of lower part of left graph; **B**: Doctoral degrees; right half represents detail of lower part of left graph. Source: Statistics Canada cited in cited in Natural Science and Engineering Research Council of Canada, 1997, report entitled *Highly Qualified Personnel*, Table B7, B9.

Canada, 1998). In addition, I hope that earth system science will play a significant role in gaining an increase for earth sciences in the NSERC system through the latest reallocation exercise.

Even though the mineral and energy industries in which we work are regarded as "old economy" industries, one has to take heart that resources will always be required to sustain all other forms of industry, including those in the "new economy." Between them, the energy and mineral industries have increased their contribution to the gross domestic product of Canada (Fig. 18); they currently account for more than 10% of GDP and have done so for years. These are not flash-in-the-pan industries; they are here for the long haul.

We need only take a look at the trends in energy trade value and energy consumption in Canada to conclude that there is an increasing market for all the ways we produce energy and an increasing demand for energy. For example, the value of exports in the energy trade has more than doubled in the last decade from about $12.5 billion in 1987 to nearly $30 billion in 1997. Similarly, the demand for energy in Canada has grown by more than a thousand trillion Btu over the last decade, according to the Canadian Energy Research Institute. Earth scientists play a major role in supplying this energy, and therefore we can feel confident about a good future for the industries in which we work. The cyclical nature of supply and demand, and hence prices of various commodities, is still underwritten by the incontrovertible *need* for these resources in Canada and around the world. In addition, many of the environmental problems caused by such activities as burning fossil fuels or poor waste management can be ameliorated by earth scientists.

THE PUBLIC MUST GET THE MESSAGE

As earth scientists, we are at the centre of knowledge that is required to make life on this planet sustainable. We must get this message across to Canadians at three levels that net three different rates of return. First, there is the short-term need to educate politicians (basically lobbying). Politicians have a 4- or 5-year life cycle, and they must therefore be educated on a continual basis. Second, we must convey our message to the public in general. Efforts in this arena net returns in the medium term. Finally, and perhaps most importantly, to change attitudes in the long term we must talk to children.

We do a very poor job of enlightening politicians; it is now critical that we do a better job. There are some signs that we are improving and one of these is that the Partnership Group for Science and Engineering (PAGSE) now runs information breakfasts for Members of Parliament under the endearing title of "Bacon and Eggheads." These sessions provide opportunities for invited scientists to convey important messages about science in the broadest sense to MPs. Members of Parliament are susceptible to lobbying in Ottawa, but they are even more vulnerable to advice from their own constituents, and I would like to advocate that we develop groups of scientists in every riding in Canada that would brief the local MP about twice a year on scientific matters of importance and on matters of importance to scientists.

We do a bit better in the medium- and long-term objectives of public awareness through the hands-on museums and science centres and many volunteer organizations across Canada that deal with the public awareness of science. As earth scientists, we connect to education through programs like EdGEO and EarthNet. The critical role of museums, science centres, and voluntary programs that reach into the public arena and also specifically into classrooms across the nation must not be underestimated in our efforts to get earth science into the hands of the public.

When I visit a Grade 3 classroom to talk about rocks and minerals, one of the exercises we go through is to try and find something in the classroom that was not extracted from the earth. In the process we connect sand with windows, petroleum with plastic seats and computer cases, metal mines with metal chairs and desks, gypsum with wall board, coal with electricity, natural gas with heat, and so on. Pretty soon, there is not a thing identified in the classroom that did not originate either from a tree or from some hole in the ground made to extract resources. If we want to keep our current standard of living we will keep needing all these resources that earth scientists find for our society. Grade 3 children and their teachers have no problem understanding this simple relationship, and while they may suggest that we take more care of the environment, they fully understand the need. Frankly, the children understand the needs and relationships better than adults.

In Canada we do earth science as well or better than anyone. As earth scientists, we are at the centre of knowledge that is required to make life on this planet sustainable. We have to convince our fellow citizens of this and insist that earth science be recognized for it. So, although we have suf-

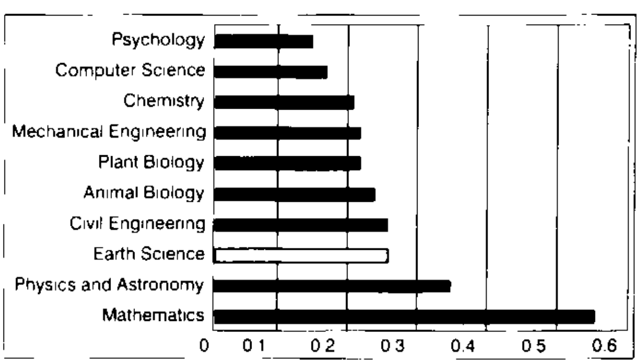

Figure 17 Faculty demand/supply index (faculty departures 1996-2002 divided by doctoral graduates (1994-2000) by discipline. Source: Natural Science and Engineering Research Council of Canada, 1997, Report entitled *Highly Qualified Personnel*, Figure 43.

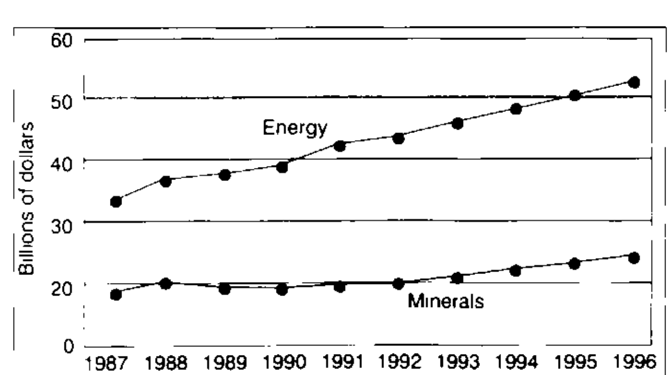

Figure 18 Contribution of minerals and energy to Canada's gross domestic product (GDP). Source: Natural Resources Canada and Statistics Canada.

fered much erosion over the decade, there is a bright future. In order to provide uplifting experience in our discipline we need to all work together and we need to integrate the various branches of our science better. As earth scientists, we know that the inevitable consequence of uplift is erosion. However, erosion has outweighed uplift in the last decade. We must try to restore the balance.

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