Geoscience Canada

The Contribution of Geoscience to Canada's Innovation Strategy: Smart tools and human resources for vibrant resource and environmental industries

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Volume 29, Number 4, December 2002

URI: https://id.erudit.org/iderudit/geocan29_4icg01

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Publisher(s)

The Geological Association of Canada

ISSN

0315-0941 (print)
1911-4850 (digital)

Explore this journal

Cite this article

Hall, J. (2002). The Contribution of Geoscience to Canada's Innovation Strategy: Smart tools and human resources for vibrant resource and environmental industries. *Geoscience Canada*, *29*(4), 179–182.

ISSUES IN CANADIAN GEOSCIENCE

The Contribution of Geoscience to Canada's Innovation Strategy: Smart tools and human resources for vibrant resource and environmental industries

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The following is the text of a submission prepared by Jeremy Hall on behalf of the Canadian Geoscience Council. It was sent in September 2002 to Industry Canada and copied to the PMO, the Ministers of Environment, Finance, Fisheries and Oceans, Natural Resources, the Secretary of State for Science and Technology, the CEOs of NSERC and CFI.

PREAMBLE

The Canadian Geoscience Council (CGC) is a federation of learned societies, technical associations, university departments and federal, provincial and territorial geological surveys, representing over 10,000 practicing Canadian geoscientists. CGC strongly supports the essence of Canada's Innovation Strategy, as proposed by Industry Canada. In this brief, CGC wishes to point out the benefits to the health and wealth of Canadians of investment in geoscience as a significant component of the Innovation Strategy.

GEOSCIENCE IN THE INNOVATION STRATEGY

Industry Canada is presently undertaking a series of public consultations on its proposed Innovation Strategy. Industrial sectors are being consulted, followed by regional meetings, leading to a national discussion later this year. Geoscience is pursued with varying vigour in Canada's regions, and it is a relevant component of several of the business sectors identified in the Industry Canada consultation process – particularly in ocean technology, environment, mining/metals/minerals, energy (especially hydrocarbons), geomatics, and academia. Because of the distribution of geoscience effort among the sectors and its dilution, in each sector, by other worthy 'disciplinary' components, we wish to reinforce the impact that smart geoscience should have in helping meet the goals of the Innovation Strategy.

Much attention and encouragement has been given by Canadian federal and provincial governments over the past decade to industries developing new, 'high-technology' products, especially in the area of information technology. By contrast, relatively little attention has been devoted to Canada's fundamental, wealth-generating industries, especially those in the resource sectors. What has been missing, or at least subdued, from the perspectives implicit in government policies, is the realization that some of the largest consumers and users of high-technology products are the resource industries, mistakenly regarded by some as 'sunset' industries, but demonstrating that they are here to stay by adapting to new challenges and competition.

The focus on information technology is appropriate. However, information technology needs populating with knowledge in order for it to have a use: geoscience knowledge can generate wealth and, in decision making, can reduce economic, environmental and health and safety risk.

Geoscience provides the explorative underpinning of the non-renewable resource industries – minerals and hydrocarbons – and, we now under-stand, of the habitat for many renewable resources, whether they be in fisheries, forestry, agriculture, or water. Further-more, geoscience serves to protect Canadians from a variety of hazards, both natural and anthropogenic. So geoscience provides tools for discovery and efficient production of resources, and helps protect Canadians from a diversity of contrary circumstances, from earthquakes and landslides, to environmental pollution and the effects of global change. Thus geoscience provides the fundamental underpinnings of sustainable development: it is about understanding Earth's surface and what lies just below. This is the surface on which we live, build extraordinarily complex edifices; it is the surface that provides all our resources, and receives all our wastes.

EXAMPLES OF INNOVATIVE GEOSCIENCE FOR CANADIANS

The following examples illustrate how geoscience uses high technology for the benefit of Canadians, both in the development of resources and in the reduction of risks to health.

The Hibernia oilfield, offshore Newfoundland, is a $12 billion R&D project! Now in the fifth year of pro-

duction, Hibernia's various reservoirs are still being developed. Innovative 'horizontal' drilling along the layers of the sandstone reservoir radically enhances commercial production in rock broken up by complex faulting, compared with drilling directly down and through. As development drilling proceeds, geoscientists and engineers monitor the drill bit in real-time in the Hibernia offices in St. John's, over 300 km away, by smart in-situ measurement, high-bandwidth digital transmission and sophisticated interactive computer display.

What about future energy production? In the Mallik gas hydrate drilling project, Canadian geoscientists and engineers are testing the huge potential of hydrocarbons that are frozen in an ice-like mass with depths of tens to hundreds of metres below the surface in regions of permafrost on land and along deep-water continental margins. Researching the thermal stability of gas hydrates by testing them in-situ with novel downhole technology is an essential step – now underway – towards their commercial production; to understanding the hazard they pose to other subsurface development; and to predicting the stability of ground in regions of permafrost affected by climate change.

Sudbury, in northern Ontario, is one of Canada's biggest mining camps, producing $2 billion a year of metal ores. There has been a huge investment in robotics in the Sudbury mines over the last two decades, so that production is maintained with a labour force only one third of what it was 20 years ago. Innovation has increased productivity by a factor of three, with major improvements in the safety of workers.

New Brunswick's long-established Bathurst mining camp produces over $0.5 billion of ore per year, and more than 2000 people are directly employed by the mining operations. Ore reserves have been dwindling. Over the last decade, the EXTECH II geoscience research program spawned an estimated $3 million a year of additional exploration expenditures. This project was a collaboration of industry, federal, provincial and U.S. geological surveys, and universities, extending across northern New Brunswick and adjacent parts of Maine. Its success was based on a comprehensive overview of the region, through the integration of new detailed geological field mapping and acquisition of high-resolution multi-parameter geophysical and geochemical data, which allow for the interpretation of bedrock geology that is only sparsely exposed in this heavily forested region. Existing deposits were 'finger-printed' by the peculiarities of their responses to different geoscientific measurements to provide new templates for exploration for new deposits. The ability to correlate different measurements by their inclusion, and manipulation, as a series of overlays in a geographic information system has led to major advances in the understanding of this important mineral belt.

According to respondents to a recent poll, more Canadian geoscientists now work in hydrogeology, environmental and geotechnical geology, than in either the energy or mining sectors. The rapid growth in the applications of geoscience to water resources, reduction of hazards, and to the construction industries, underscores both the increasing realization of their significance, and to their ability to contribute economic value through innovation.

Major engineering projects are being developed for the installation of pipelines, whether they be on land to bring gas from the Arctic across northern Canada, or at sea to take gas from offshore east coast fields to landward markets. These are large, capital-intensive projects that require substantial geotechnical input to establish optimal routes. At sea, for example, the use of cutting-edge swath bathymetry, in conjunction with seabed sampling to determine the geotechnical characteristics of proposed routes, is a prime example of economic risk-reduction through the use of current technology in today's Canadian marine civil engineering projects.

Groundwater in Canada is now becoming recognized as a resource that needs careful management to maintain its long-term availability and quality. New hydrogeological assessments of Canada's most valuable aquifers are underway on a scale never before attempted, using in-situ monitoring, surficial, bedrock and borehole mapping. Integration in 3-D models using GIS tools forms the basis of computer reconstruction of each aquifer. These studies are directed to quantification of reserves, and their renewability, and to the modelling of effects of pollution from potential point contaminant sources. Effective modelling of aquifer replenishment and of potential contaminants uses the highest-performance computers and new software codes that deal with 3-D flow and multiple immiscible fluid phases.

The examples cited are just a few of many that could be offered to show how innovative geoscientists with good ideas and new tools are enhancing the impact of geoscience on Canada's future. From the standpoint of information technology, two particular aspects are diffusing rapidly into modern geoscience in Canada. Computer visualization of the Earth in the three spatial dimensions is accelerating in its use. Virtual reality devices that offer big-screen 3-D immersive visualization are being used by asset teams of geoscientists, engineers and economists to determine the optimal routes for production drilling of oil reservoirs. Time-lapse repetitions of reservoir visualizations are also offering 4-D insight into the effectiveness of production strategies, and how they might be improved. This exciting technology is now finding novel applications in mining, groundwater resource development, and in testing the ability of coal beds and mature oil fields to sequester carbon dioxide. The rapid expansion of knowledge generated by these new technologies is of most value to Canadians when it is readily accessible to all – developers, planners, policy-makers, regulators, and the general public. Governments and the private sector – often in collaboration – are now making major investments to make digital geoscience data accessible. Informed decision-making should be based on the best possible information and ready analysis of the relationships

to be found within it: now, through these commendable efforts, the information is getting out to those who need it.

THE INNOVATION STRATEGY ACTION PLAN: MAXIMIZING THE POTENTIAL CONTRIBUTION OF GEOSCIENCE

How can the lessons of these success stories be used to drive a geoscience component of the Innovation Strategy? What can the public sector – research funding agencies and government ministries responsible for geoscience – do to enhance the role of geoscience in innovation? How can such investments help the private sector enhance Canada's R&D capacity, as intended? Several themes stem from this discussion.

1. Geological mapping of Canada's exposed rocks is vitally important, but its inclusion as a component with multi-parameter, high-resolution characterization (remote sensing, in the broadest sense) and visualization of the upper few kilometres of the Earth is much more likely to lead to new resource discoveries, better hazard mitigation, and more informed decision-making in exploitation of the shallow Earth.

2. Training, in these new multifaceted geoscience approaches, of the students that will become tomorrow's explorers is growing in importance as impending retirements from industry, geological surveys, and academia loom.

3. The contribution of public funds to facilitate, and undertake, new geoscience research will accelerate innovation.

4. The competitiveness of Canada and Canadian industry in geoscience fields depends on their use and, where appropriate, development of smart new tools that give them competitive advantage. The tools may be field hardware, interpretative software, or anything in between.

These themes can be pursued in various ways, so the following suggestions are merely illustrative of what government and research funding agencies might do to facilitate the contribution of geoscience to enhancing R&D in Canada. The suggestions respond to the three challenges in Industry Canada's paper on the Innovation Strategy, "Achieving Excellence."

The Knowledge Performance Challenge

The following examples recommend specific programs that might be developed by federal departments and/or research-granting agencies. They involve partnership, and for this to be successful, each partner must have adequate resources to fulfil its role. This indicates a need of increased federal funding that sustains basic science and engineering functions in government and universities, and tax incentives that attract greater R&D investment in the private sector.

Characterization of the Earth's uppermost crust

Encourage the development of partnerships among government, universities and the private sector directed to multi-parameter high-resolution physical and chemical characterization of the Earth's uppermost crust. Some of these might be focused on specific economic targets, such as the Bathurst mining camp example. Others might be more broadly based – we might want to encourage a 'glass Earth' project to characterize the top 3 km of Canada's crust (in which lie Canada's future mineral reserves and much of its potable water), or a 'transparent ocean' project that will provide new images of the seafloor in, and adjacent to, Canada's marine land (and so provide for more efficient development and superior management of the seabed and its resources – fish, shellfish, minerals). There is significant potential for Canadian small and medium enterprises (SMEs) to develop new technologies for export in the form of services and tools from such investment.

The results would include much greater knowledge of that part of the Earth critical for resources, and for environmental risk management. The ultimate measures of success would be discoveries of new resources; reduced incidence of, and better mitigation of, hazards such as earthquakes, landslides, floods, water contamination, and climate change; development of smart Earth-imaging tools; and enhanced international activities of Canadian SMEs.

Sustainable Development of Resources

Encourage the development of partnerships among government, universities and the private sector directed to collaborative research that addresses sustainable development of resources in a holistic manner, involving geoscience in a multitiered network of inter-related issues of exploration, production, refining and reclamation and, on a wider base, economics, sociology and politics.

The results would include much broader understanding of the complexities surrounding the exploration, production and restoration of sites of resource extraction. Applied to Canada's northern regions, which are likely to contain a high proportion of Canada's untapped mineral wealth, the research should yield strategies for exploitation that minimize negative legacies for future generations, while providing income for residents of northern communities.

Smart Tools

Encourage a research focus on 'smart tools.' Academic and government geoscience research in Canada has won international plaudits for its contributions to understanding how the Earth works, especially through the last four decades of the plate tectonic 'revolution'. However the development of the tools for making these contributions has been only an occasional side-product from these efforts. A modest shift, perhaps by the addition of a new strategic program aimed at 'smart tools,' would be attractive. But it must be recognized, by funding agencies and applicants, that this kind of research involves much higher risk than the 'safer' proposals commonly directed at the standard research council grants competitions, which guarantee renewal in the normal 3 to 5 year round.

The results would be increased availability of Canadian-designed and built hardware and software for geoscience activities, in resource exploration, and geotechnics applied to environmental and engineering projects, all with major opportunities for winning export sales.

The Skills Challenge

The desired outcome of the Innovation Strategy is a much greater investment in R&D by the private sector. Some of the federal funding to facilitate this must be invested to supply the human resources required. On the supply side, there are global resources that can be tapped more effectively by streamlining immigration policies, as indicated in Innovation Strategy papers. However, Canadians should also enhance opportunities for their own children to contribute to the Innovation Strategy. So, in supporting Industry Canada's suggestions for training of new graduates, we indicate specific elements that would have special value.

A. Provide additional support for collaborative undergraduate and postgraduate training in modern geoscience exploration, by co-operative programs that are a formal part of university programs or by new or enhanced funding programs of scholarships for collaborative projects of academia with geological surveys or industry or both. This would enhance the opportunities for exposure of students to modern geoscience technology used by government and industry.

B. Increase funding for research studentships, especially for those pursuing collaborative studies with industry, geological surveys or both, in order to attract the brightest students into geoscience.

C. Introduce scholarships for course-based Master's degree programs. Vocational courses in geoscience are relatively rare in Canada, yet fundamental training in geoscience exploration applied to specific target industries, resource-based, environmental or geotechnical, is essential to the operational science and engineering activities of those industries. The essential broadening of undergraduate curricula to embrace Earth systems makes it more difficult at that level to provide adequate vocational training. Graduate degrees in research, on the other hand, require a high level of specialization for that research to be competitive. Course-based Masters could fill the growing gap in the spectrum of graduating expertise.

The results of these programs would be an enhanced supply of geoscience graduates, with a range of capabilities matched to the levels of opportunities offered by Canadian geoscience employers, and skill sets that are appropriate for driving R&D in the private sector.

The Innovation Environment Challenge

Implementing many of the above suggestions would help meet this challenge for the geoscience sector. Of the Industry Canada goals identified under this heading, improving the incentives for innovation should be of very high priority. By enhancing the opportunities described above for collaboration among industry, government and academia, there may be enough of a culture shift to generate the stronger interaction sought among these sectors. Canada has a formidable reputation for innovation in geoscience but recent history, particularly the increased multinational ownership of resource industries and the priorities of executives to provide shareholders with value, has reduced investment in geoscience R&D in Canada. Strong incentives to reverse this decline, including tax concessions for industrial contributions to the programs suggested here, would be invaluable.