GEOSCIENCE CANADA

JOURNAL OF THE GEOLOGICAL ASSOCIATION OF CANADA
JOURNAL DE L'ASSOCIATION GÉOLOGIQUE DU CANADA

SEPTEMBER 2004 VOLUME 31 NUMBER 3 GSCNA3 31 97-144
SEPTEMBRE 2004 VOLUME 31 NUMÉRO 3

PRESIDENTIAL ADDRESS

Geoscience for the Needs of Canadians GAC Presidential Address, Annual Meeting St. Catharines, Ontario 12 May 2004

L. Harvey Thorleifson
University of Minnesota
Minnesota Geological Survey
2642 University Ave W
St Paul, MN 55114-1057 USA
thorleif@umn.edu

Geology plays an increasingly critical role in our society. Whether helping to ensure our health, secure our heritage, enhance our wealth, or to augment our security, the geosciences affect all aspects of our lives. We do this work in the earth sciences to protect our water, cope with our climate, support construction, deal with toxic substances, manage our waste, prepare for hazards, ensure our supply of energy and materials, know and protect our land, survey and manage our oceans, understand the history of life, and to comprehend our planet Earth. The Geological Association of Canada (GAC) can best serve Canadians by effectively supporting the progress of the entire Canadian geoscience knowledge sector, thus complementing the roles of geoscience-related business and professional groups. The measure of our success can be the pace at which new geoscience knowledge is being acquired, and the degree to which this new knowledge is enhancing the lives of Canadians.

NEEDS

Canadian geologists are contributing a broad Earth science approach to an ever-widening list of needs. We help ensure health by addressing toxic substances and waste disposal, and we secure our heritage by providing an understanding of our land, our oceans, the history of life, and a comprehension of our planet. We enhance our wealth by ensuring a supply of energy and materials, and by facilitating construction and land use management. We augment our security by helping society prepare for and cope with climate change and hazards. And we have broad contributions to make to the study of water, which, more than any other topic, comprehensively dictates our well-being.

Climate

The climate change debate requires insights into how the global climate system works, so that linkages are better understood, and scenarios for what can occur are outlined. This requires insight into the carbon cycle as well as climate trends and events throughout Earth history. And consideration of the impacts that climate change will have and how we can adapt to these changes requires work on topics such as permafrost stability and groundwater recharge.

Construction

All engineering activity on the land requires knowledge of the substrate, in relation to excavation, drainage and availability of materials. Optimal contributions of geological knowledge to these activities are critical to keeping costs down and ensuring good design.

Earth

Geology is the discipline that allows us to understand our home. As our perturbations intensify, there is an ever more urgent need for us to fully understand how atmosphere, biota, oceans, freshwater, glaciers, soil, volcanoes, sediment, rock, and Earth evolution as a whole interact.

Energy

The search for energy resources has been at the forefront of Canadian geology since the inception of our field, when coal was the primary target, and this focus continues today in the search for oil and gas, as well as topics such as uranium, gas hydrates, and geothermal resources. In our energy capital, Calgary, the geoscience community is active and vibrant.

Hazards

As our insights intensify, and as population and vulnerable infrastructure increase, we are being called upon to help defend Canadians from natural phenomena that cause injury and damage. Catastrophic threats include earthquakes, tsunamis, landslides, floods, volcanoes, windstorms, extreme precipitation, magnetic storms, avalanches, and impacts, while chronic hazards include shoreline erosion, wind erosion, and permafrost degradation. We can augment local knowledge regarding processes, we can outline the character of events predating observations, and we can assess factors that may be changing risk.

Land

Canada consists of a people, and we also consist of a landmass. We know and understand this landmass primarily on the basis of the knowledge accumulated by the people who have lived on the land. And we as scientists can contribute immensely to this knowledge. In many regions, our activity in working out regional geology is one of the only ways that we occupy the land, so our work is

a key to establishing sovereignty, especially in the Arctic.

Life

One of the most rapidly expanding fields at present are the genetic sciences. We can contribute to the fundamental understanding of this topic by explaining how genomes came about, the timescales involved, and the processes by which biological evolution takes place.

Materials

Mineral exploration conferences in Toronto, Vancouver, and across Canada, as well as the international role played by our financial markets, are shining beacons of Canadian leadership in this field. We are world leaders in geophysical surveys, and progress is active in geochemical methods. The diamond boom taught us how tremendously powerful and sensitive indicator mineral methods are. So whether the markets dictate that there is a need for base metals, precious metals, gemstones, industrial minerals, or emerging high-tech materials, our knowledge is rapidly advancing regarding what likely is out there to be found, how to find these materials, and how to mine them in an acceptable manner. By providing this knowledge, we are the front end of the materials flow that fuels our economy and thus our way of life.

Oceans

Our oceans are our most mysterious frontier. And the challenges and needs with respect to our large lakes are comparable to those of the oceans. Physical and biological oceanographic investigations closely linked to seafloor mapping and offshore geological investigations are the key to understanding and managing our oceans. New technology is allowing us to map bathymetry in vastly greater detail, studies of marine habitat are linking biology and geology, while new drill ships are opening exciting new opportunities.

Toxics

As our knowledge advances, we have a progressively lower tolerance for deleterious materials in our food and water, particularly with respect to their impact on children. Industrial effluent is being curtailed where the benefit to society is greater than the cost. Assessing options, however, requires a full knowledge of what is contamination and what is natural. And where the deleterious material, such as arsenic in drinking water, is natural, a geological explanation is required. If a community is told that their drinking water is contaminated, they will blame the nearest industry until they are presented with a plausible geological explanation.

Waste

Our highest priority with respect to waste disposal is to reduce our production of waste, but we are far from achieving zero waste production, and it is unclear that the cost will ever justify the benefit. We therefore will continue to discard wastes, and we have a large legacy of produced waste. A critical input to planning waste disposal is the geological integrity of the disposal site, whether for municipal garbage or high-level nuclear fuel waste.

Water

Geologists can provide an understanding of the source of deleterious elements in our source water, we can help protect water from contamination, we can design remediation, we can show how groundwater discharge governs wildlife habitat, we can help wisely utilize and manage water resources for drinking water, agriculture, industry, energy production, hydroelectric power generation, as well as shipping, and we can assist public debate by comprehending water-related hazards such as flooding and shoreline erosion.

ROLES

We are applying a broad and well-coordinated range of approaches to serving the needs of Canadians. Mapping accounts for spatial trends, while monitoring assesses temporal trends. Research obtains answers to conceptual questions. Exploration facilitates business decisions, consultants ensure good design, while synthesis reviews progress and sets priorities. Education passes on existing knowledge while facilitating its progresses, outreach better equips our society to be good stewards and helps ensure our future, while advocacy influences decision-making to enhance the standing of our profession for the good of society as a whole. Some of us have responsibilities in regulation, management, and ongoing field activities, while our work is facilitated by required consultation and coordination.

INNOVATION

Geological mapping is an example of a field in which innovation is rapidly progressing in order to optimally serve the needs of society. In the 1980s, we witnessed the final days of the paper map era. In the 1990s, we learned how to make a paper map with a computer. And in the current decade, it is time to shed the constraints that paper maps imposed on us, and implement the digital, interactive, and 3-D geological map of the future.

We are now shouldering the huge task of vector digitizing and reconciling legacy geological maps, while multiple generations of legends are being made accessible in a consistent and categorized format. Regional 3-D geological models that integrate soils and geology, surficial and bedrock geology, as well as onshore and offshore, are increasingly in demand as the information, technology, and protocols to build them progress, and the needs for such models intensify. Applications such as regional groundwater modeling require digitizing, reconciliation, and assembly of a digital elevation model, bathymetry, offshore geology, soils, surficial geology, all public domain drillhole, geophysical, and geochemical data, bedrock maps, and existing stratigraphic models typically expressed as structure contours.

In the geological map of the future, outliers will no longer be cut into the underlying stratum, as has been the case in conventional geological cartography, but will instead be stacked so that the polygons can be lifted up to depict what lies below according to the predictions and observations of the

mapper. New stratigraphic modelling, particularly required for sediments in many of our regions, requires benchmark information from cored holes logged by geologists as well as geophysical surveys, such that these high-quality results may be extrapolated laterally using drillhole data, commonly large quantities of water-well data of varying resolution and reliability.

Much effort is required to adequately georeference drillhole data in three dimensions, and to parse large numbers of unique lithological descriptions into attributes and defined terminology. Stratigraphic modelling methods ideally use all available data and an approach that permits judgement in the acceptance or rejection of data, while interpolation and extrapolation must be guided by insights into the history and processes responsible for the deposits.

Three-dimensional models can be captured as the extent of each stratum and a grid of elevations that together make up predicted stratigraphy profiles conveying expert opinion on interpolation and extrapolation from the data points, including the best available prediction of what lies below areas from which we have no data.

Reconciliation of mapping with that of neighbouring jurisdictions is a critical step, as is balancing subjective definition of strata with more objective geostatistical approaches to characterizing the heterogeneous physical properties of each stratum. Rapid progress in 3D approaches is readily achievable in undeformed sedimentary strata, while deformed strata as well as igneous and metamorphic terrane require a separate set of approaches.

Increasingly, databases of observations and measurements are being retained alongside the interpreted model, and models are being assigned varying confidence levels such that the result is seen not as an end but a means for prioritizing new mapping based on confidence and priority. Geochemical and geophysical mapping more and more will be quantitatively integrated with depictions of lithology, stratigraphy, and structure. Groundwater and thermal modeling based on 3-D geological models is a way to stimulate the organization of input information, and to set priorities for new mapping, monitoring, and research on methods and processes, rather than being an activity that must await the perfection of inputs.

Current activity is progressing from paper maps to digital models, from plan view maps to comprehensive drillhole, geochemical, and geophysical databases, as well as to 3-D models, and from static to dynamic models. Pressing user requirements demand that our work rapidly advance along this progression, in order to adequately serve the urgent needs of our society.

THE INDUSTRY

We are the Canadian geoscience knowledge industry. Our revenue is funding, and our product is knowledge. The sectors of this industry are hydrocarbon exploration, mineral exploration, geotechnical and environmental consulting, the federal geological survey, provincial and territorial geological surveys, and research.

Our largest sector in geoscience knowledge generation, by far, is exploration for oil and gas. Recent expenditures in hydrocarbon exploration have been about $6B per year, about half of which is spent on drilling, with the remainder split between geological and geophysical surveys, as well as land acquisitions and rentals. These investments in knowledge support an energy industry that provides over 6% of Canadian GDP, at $65B per year in sales, and direct employment of 225,000 people.

The most recent 'Overview of Trends in Canadian Mineral Exploration' indicates that expenditures have recently been about $500M per year. Easier access to financing, a rising gold price and a sustained search for diamonds have contributed to recent buoyancy. And governments have been highly innovative in supporting and promoting mineral exploration through fiscal incentives, the resolution of land access issues, and the provision of geoscientific data. These investments in knowledge support a mining industry that provides 4% of Canadian GDP, at $38B per year in sales, and direct employment of 355,000 people.

Sales of geoscience knowledge by consultants in the geotechnical field, such as slope stability and foundation analysis, and environmental fields, including topics such as water supply and waste disposal, can be estimated on the basis of a Canadian Geoscience Council census carried out in 2001 that found that 12% of the 3000 respondents were in this field. Based on an estimated total of at least 12,000 geoscientists in Canada, this implies a total of 1500 practitioners in this field who would each be supported by over $100k in revenue per year, implying about $200M in annual revenue for this sector of the industry.

Geological Survey agencies carry out the geological, geophysical, and geochemical mapping that we require. Provincial and Territorial surveys map their regions, while the GSC addresses cross-border topics, brings specialization to cooperation with provinces and territories, and addresses topics left to the federal survey. Along with their core mapping and monitoring roles, Surveys carry out conceptual research to ensure that their activity is linked to conceptual advances, and to ensure that their scientists are experts in their fields. The total GSC budget is about $70M, while funding for Provincial and Territorial surveys is $60M per year.

Total annual funding to basic geoscience research in Canada, primarily distributed by NSERC, is about $50M - about half grants and half research partnerships, along with training support. With accompanying salaries and overhead, this is an activity that adds up to about $100M per year. Our success in competing for research funds in recent years has not been as impressive as that achieved by some other fields, leading to calls for greater effort in defining research targets, pursuing funding for them, attracting excellent scientists, and enhancing public awareness of the value of the work. This funding supports the educators and researchers in schools, universities, or museums who ensure our future.

The Canadian geoscience knowledge industry thus is driven by a $6B annual investment in hydrocarbon

exploration, $500M in mineral exploration, $200M in geotechnical and environmental geoscience consulting, $130M per year in geological surveys, and $100M per year in basic geoscience research - an industry that adds up to about $7B per year, about 1% of Canada's $1050B GDP. This investment sustains production that exceeds more than a $100B per year, more than a 10% contribution to GDP - a 10:1 multiplier and activity that directly employs well over a half million Canadians.

THE COMMUNITY

This activity is carried out by geoscientists whose contribution and progress is facilitated by a well-coordinated spectrum of geoscience and geoscience-related societies that play a vital role in serving the needs of Canadians. The Canadian Geoscience Council (CGC) is the meeting place for three sectors that vary in the way that they measure success. The first group consists of business associations who measure success in the form of profitability that is optimized through administrative arrangements that support rather than impede the level of activity. The second group consists of those who tend to professional registration and mobility. The third group optimizes the progress of knowledge through activities such as research, mapping, and monitoring, commonly measured on the basis of total funding.

CGC facilitates coordination of this continuum of business, professional, and scientific societies. CGC appoints expert panels, comments on legislation, promotes awareness and education of geoscience, encourages talented young Canadians to consider careers in the earth sciences, and facilitates outreach. In addition to these activities that serve needs shared by business, profession, and science, CGC also has joined with GAC in leading activities that are purely science-based, including facilitation of science initiatives, organizing Canada's participation in global research programs, and acting as the international voice of Canadian geoscience.

Business-based groups such as the Prospectors and Developers Association of Canada (PDAC), Canadian Association of Petroleum Producers (CAPP), BC & Yukon Chamber of Mines (BCYCM), the Mining Association of Canada (MAC), and to some extent the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) speak for geoscience-related business sectors. PDAC represents the mineral exploration industry, CAPP is the voice of Canada's oil and natural gas industry, the Mining Association promotes Canada's mining and mineral-processing industry, CIM is the leading technical society in the Canadian minerals, metals, materials and energy industries, while BCYCM is Canada's oldest mining association.

Parties who seek to optimize professional registration and mobility include provincial licensing associations and their coordinating body, the Canadian Council of Professional Geoscientists (CCPG), which speaks for the regulated geoscience profession in eleven of the thirteen provinces and territories. More than 7,600 geoscientists are licensed in Canada, and CCPG expects this number to reach 10,000 within two to three years. An essential role for CCPG is promotion of professional development, and much of this activity is best delivered by scientific and technical societies, due to their role in encouraging research and disseminating new information.

Specialist societies who facilitate the progress of geoscience knowledge in Canada include groups such as Association of Exploration Geochemists, Canadian Association of Geographers, Canadian Exploration Geophysicists Society, Canadian Geophysical Union, Canadian Geotechnical Society, Canadian Meteorological and Oceanographic Society, Canadian National Chapter of the International Association of Hydrogeologists, Canadian Quaternary Association, Canadian Society for Coal Science and Organic Petrology, Canadian Society of Exploration Geophysicists (CSEG), Canadian Society of Petroleum Geologists (CSPG), Canadian Society of Soil Science, Canadian Well Logging Society, Institute for Lake Superior Geology, International Association for Great Lakes Research, Mineralogical Association of Canada, and Society of Economic Geologists.

Some of Canada's most active earth science specialist groups function within GAC, including Canadian Geomorphology Research Group, Canadian Sedimentology Research Group, Environmental Earth Science Division, Geomatics Division, Geophysics Division, Isotope Science Division, Marine Geosciences Division, Mineral Deposits Division, Paleontology Division, Precambrian Division, Structural Geology and Tectonics Division, and the Volcanology and Igneous Petrology Division.

Canadian earth scientists also optimize their activity through regional groups, such as the GAC Pacific Section, the GAC Cordilleran Section, the Calgary-based groups such as CSPG and CSEG, the GAC Edmonton Section, the Saskatchewan Geological Society, the GAC Winnipeg Section, the Sudbury and Toronto Geological Discussion Groups, an emerging Québec geoscience society, the Atlantic Geoscience Society, and the GAC Newfoundland Section.

Crosscutting these groupings are the very large consultation and coordination roles played by the Committee of Provincial Geologists, the Council of Chairs of Canadian Earth Science Departments, and the Geological Survey of Canada. And as we all age and as the baby boom demographic bulge enters late career, we are acquiring wealth, increasing our benevolence, and planning their legacy, so the Canadian Geological Foundation will play a larger and larger role in receiving and distributing financial resources for the good of Canadian earth science as a whole.

THE ROLE OF GAC

The challenge for GAC is to serve the full range of Canadian earth science, while respecting the lead role of business and professional groups in their fields. GAC does so through three business lines, a Communications Committee sustained by membership

sales, a Program Committee that runs competitive, financially self-supporting conferences, and a Publications Committee that facilitates books and periodicals sufficiently compelling and attractive to our scientific community to be profitable. The GAC Finance Committee tends to governance in an efficient and effective manner that is supported by corporate membership sales and fundraising.

In the field of Communications, we communicate with members through Geolog and e-communications, with prospective members through membership drive, with University communities through campus representatives and student chapters, with constituent communities through lecture tours, Sections, and Divisions, with the Canadian geoscience community through our Awards program and Geoscience Canada, with policy-makers through advocacy, and with the general public through outreach. Outreach influences outcomes in the medium to long term, while advocacy is designed to influence decision-making in the short term. GAC outreach helps Canadians to appreciate the natural world, thereby assisting them in making wise decisions regarding resource management, response to geological hazards, and environmental stewardship, and promotes the importance of the profession, thereby attracting capable persons to careers in our field. In advocacy, GAC is active on Parliament Hill through the Partnership Group for Science and Engineering, we coordinate with specialist groups and CGC, we speak for Canadian earth science at times of active public debate, and we work to optimize funding to Canadian earth science. GAC Awards define and promote models for members of our profession to aspire to. Our lecture tours facilitate communication, and our e-communications minimize paper mail by optimizing our web site, bulletins and email list. GAC Sections & Divisions support the needs of specialist and regional groups, while we equally recognize corresponding independent groups. And our Student Chapters and Student Prize provide a constructive GAC role on campuses. In the field of membership drive, communication with current and prospective members facilitates member retention and recruitment, and identifies priorities for enhancements to the Association. Interaction with current members determines their level of satisfaction and increases their likelihood of renewal. Contact with persons wishing to become members is designed to answer questions and provide a membership application form. Communication with prospective members indicates the benefits of membership, and identifies issues that are preventing prospective members from joining, so that we can respond to these concerns.

The GAC Program Committee facilitates conferences and short courses that are a key factor in the progress of our science and interaction in our community. Our broad membership and partnerships ensure that our annual meeting attracts the widest cross-section of the Canadian earth science community. Much effort is put into the selection of optimal venues, construction of an attractive program, working out co-sponsorship, developing international partnerships, conducting effective marketing, ensuring appropriate timing, arranging periodic major events, and ensuring high quality short courses and workshops. Our Nuna meetings play a key role in specialized fields. We strongly support our volunteer local organizing committees, whose good will and hard work are the keys to success. We increasingly partner with Canadian specialist societies to maximize the scope and attractiveness of our annual conference, we are working with international partners such as GSA, and we are promoting major events, such as the planned GeoCanada 2010.

The GAC Publications Committee plays a critical role in the progress of Canadian earth science by ensuring the publication of books and periodicals that ensure the free flow of information on our research and professional community activity. Geoscience Canada and our highly popular newsletter Geolog are the broadest communication vehicles in the Canadian earth science community. Geoscience Canada is our widely respected, quarterly journal that publishes papers of broad interest on the status of and developments in the science and profession. Review papers are published to describe progress in a field, topical articles discuss the interaction of the profession and society, and short notes present the results of research. Also included are features, series articles, conference reports and book reviews.

The GAC Finance Committee tends to GAC governance in an efficient and effective manner that is supported by corporate membership sales and fundraising. We encourage direct donations of funds to GAC, and we actively support the Canadian Geological Foundation (CGF), including every effort to maximize donations and bequests.

CONCLUSION

Canadian earth sciences will prosper as we focus our efforts on the needs of our society, and as we produce what is needed in a format that can be readily used by a broad range of clients. While doing so, we will continue to take a broad approach to our work, to ensure the progress of fundamental knowledge, to facilitate serendipity, and to prepare ourselves for unanticipated requirements. By relentlessly taking this approach, and by repeatedly re-inventing ourselves, Canadian geoscientists will have a secure future.

GAC can best serve Canada by effectively supporting the progress of the entire Canadian geoscience knowledge sector, and by working to optimize efficiency and effectiveness in the acquisition of geoscience knowledge. The measure of our success can be the pace at which knowledge is acquired, and the degree to which this new knowledge is enhancing the lives of Canadians. We can achieve this by strongly supporting the role of all specialist groups, by obtaining the support and recognition of the entire Canadian earth science community, and by working in cooperation and coordination with business and professional groups through the Canadian Geoscience Council.

SERIES

Igneous Rock Associations in Canada 3. Large Igneous Provinces (LIPs) in Canada and Adjacent Regions: 3 Ga to Present

R.E. Ernst and K.L. Buchan
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8
rernst@NRCan.gc.ca

SUMMARY

Earth history is punctuated by numerous periods during which large volumes of mafic magma were emplaced. Such magmas not generated by a 'normal' spreading ridge or by subduction are termed Large Igneous Provinces (LIPs), and consist of continental flood basalts, volcanic rifted margins, oceanic plateaus, ocean basin flood basalts, submarine ridges, and seamount chains. Associated felsic rocks may also be present. LIPs of Mesozoic and Cenozoic age are typically the best preserved. Those of Paleozoic and Proterozoic age are usually more deeply eroded, and consist of flood basalt remnants and a deep-level plumbing system (of giant dyke swarms, sill provinces and layered intrusions). In the Archean the most promising LIP candidates are greenstone belts containing komatiites. Many LIPs have been linked to regional-scale uplift, continental rifting and breakup, and climatic crises. They can be used as precisely dated time markers in the stratigraphic record, and are key targets for Ni-Cu-PGE exploration. LIPs have also become a focus in the debate on the existence and nature of mantle plumes.

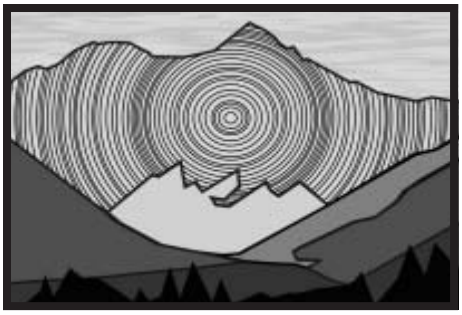
Canada has a rich record of LIPs. At least 80 candidates are recognized in Canada and adjacent regions, with ages ranging from 3100 to 17 Ma. We review proposed links between the LIP record of Canada and mantle plumes, continental breakup, regional uplift, and ore deposits. However, given that many mafic units in Canada remain poorly characterized, a concerted geochronology campaign with integrated paleomagnetism and geochemistry would be invaluable in expanding the application of the Canadian LIP record to solving major geological problems.

RÉSUMÉ

L'histoire de la Terre est ponctuée de nombreuses périodes de mise en place de forts volumes de magma mafiques. De tels magmas qui ne sont pas issus de zones d'expansion « normale » ou de subduction sont appelés Grandes provinces ignées (GPI), et celles-ci sont constituées de basaltes d'épanchements continentaux, de marges de fosse volcaniques, de plateaux océaniques, d'épanchements de basaltes de bassins océaniques, de crêtes sous-marines, et de chaînes de monts sous-marines. Peuvent également y être associées des suites de roches felsiques. Généralement, les GPI du Mésozoïque et du Cénozoïque sont les mieux préservées. Celles du Protérozoïque et du Paléozoïque sont généralement plus fortement érodées et sont constituées de vestiges de basaltes d'épanchement et des réseaux de conduits d'origine (réseaux géants de dykes, provinces de filons-couches et d'intrusifs stratifiées). Dans l'Archéen, les meilleurs candidats sont représentés par les bandes de roches vertes à komatiites. De nombreuses GPI ont été associées à des épisodes de soulèvement régionaux, de dérives ou de fragmentations continentales, ainsi qu'à des crises climatiques. Elles peuvent servir de marqueurs temporels stratigraphiques et sont des cibles de première importance dans l'exploration de gisements de Cu-Ni-ÉGP. Les GPI sont aussi devenues des arguments très considérés dans le débat sur l'existence et la nature des panaches mantelliques.

Le Canada possède de riches archives de GPI, et au moins 80 candidatures ont été isolées sur le territoire canadien et dans les régions adjacentes, leur âge délimitant une fourchette allant de 3 100 Ma à 17 Ma. Nous passons en revue les liens proposés entre la suite des GDI canadiennes d'une part, et celle des panaches mantelliques, des fragmentations continentales, des soulèvements régionaux, et des gisements minéraux, d'autre part. Toutefois, vu le piètre état de caractérisation des unités mafiques au Canada, une campagne de caractérisation géochronologique, paléomagnétique et géochimique serait d'une valeur inestimable pour favoriser l'utilisation des GDI canadiennes pour nous aider à solutionner de grands problèmes géologiques.

ARTICLE



Environmental Change in Garibaldi Provincial Park, Southern Coast Mountains, British Columbia

Johannes Koch[1*], Brian Menounos[2], John J. Clague[1], and Gerald D. Osborn[3]

[1]Department of Earth Sciences, Simon Fraser University, Burnaby, B.C., V5A 1S6
**jkoch@sfu.ca*
[2]Geography Program, University of Northern British Columbia Prince George, BC, V2N 4Z9
[3]Department of Geology and Geophysics University of Calgary, Calgary, AB, T2N 1N4

SUMMARY

We are reconstructing Holocene environments in Garibaldi Provincial Park, in the southern Coast Mountains of British Columbia, by examining a diverse set of paleoenvironmental records, including tree-rings, lake sediments, glacial landforms, and photographs. This integrated study, in combination with previous research in adjacent areas, is providing a more detailed picture of past climate, vegetation, and glacier extent in Garibaldi Park than has heretofore been available. The data suggest recurrent, complex, and successively more extensive glacier advances during the last half of the Holocene, followed by dramatic warming, snow and ice loss, and a rise in treeline in the twentieth century. The multi-proxy approach used in this study is broadly applicable to other mountain areas. It yields more reliable and robust paleoenvironmental reconstructions than approaches based on only one or two types of data.

RÉSUMÉ

Nous travaillons à reconstituer les conditions environnementales holocènes dans le parc provincial Garibaldi, dans la région sud des montagnes côtières de la Colombie-Britannique, en étudiant divers ensembles de variables représentatives du paléoenvironnement, dont les anneaux de croissance des arbres, les sédiments lacustres, les formes des paysages glaciaires, et des photographies. La présente étude synoptique, combinée aux résultats des recherches sur des régions adjacentes, nous fournit une image plus détaillée du climat, de la végétation et de l'étendue glaciaire d'alors dans le parc Garibaldi. Les données permettent de penser que durant la dernière moitié de l'Holocène, les avancées glaciaires ont été récurrentes, complexes et de plus en plus étendues. Par la suite, il y a eu réchauffement spectaculaire, déperdition de neige et glace, ainsi qu'une élévation de latitude de la limite forestière au cours du XX[e] siècle. L'approche par combinaisons de variables représentatives utilisées dans la présente recherche peut être employée tel quel pour l'étude d'autres régions montagneuses. Les reconstitutions paléo-environnementales sont plus fiables et plus sûres que celles reposant sur un ou deux types de données.