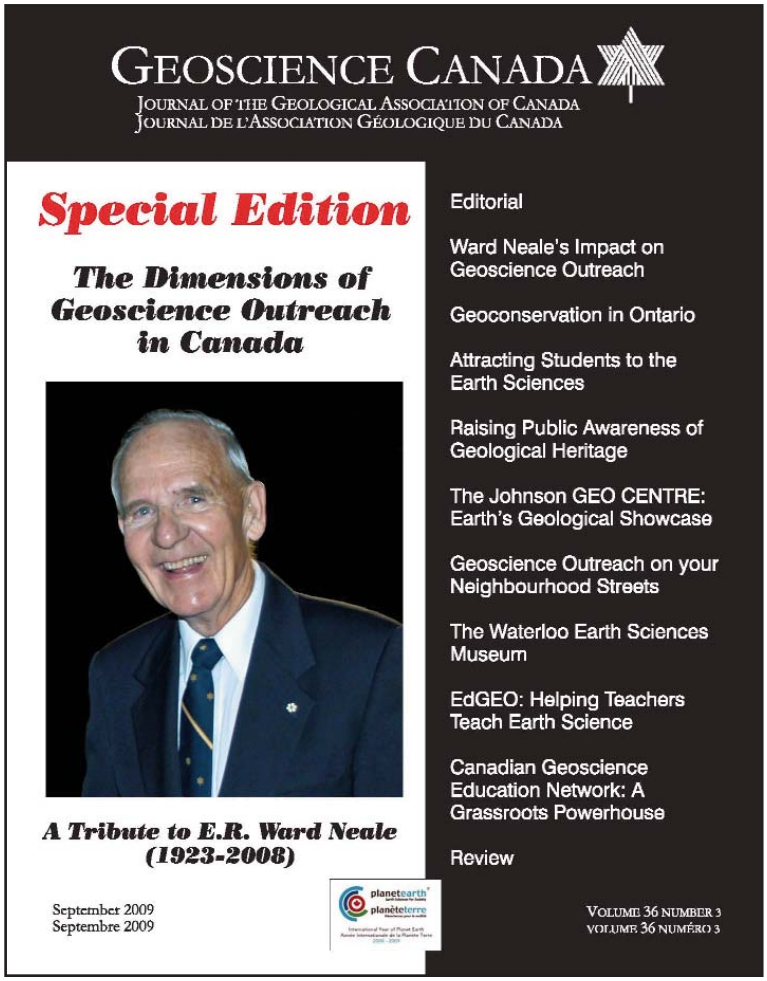
SPECIAL TRIBUTE ISSUE

As a special tribute to one of GAC's greatest supporters and friends, the late Ward Neale, this issue of *Geoscience Canada* is being made available in its entirety free of charge. The file may be printed for distribution, and we encourage you to forward the URL to your friends. Please do not post the journal to any website, however you can certainly link to it through your own website.

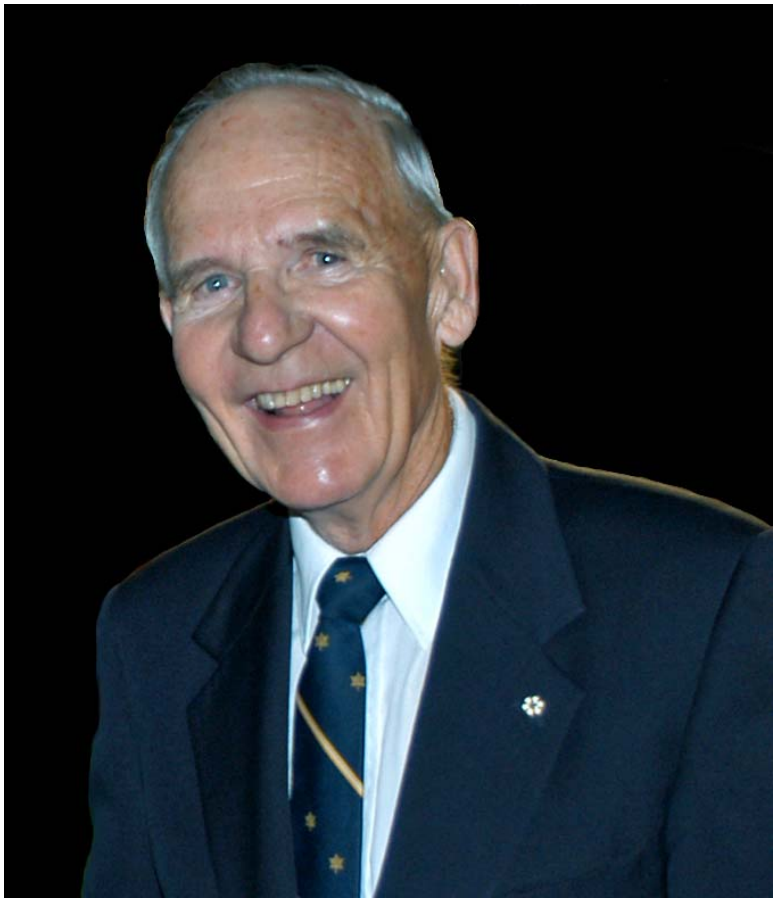
We hope you enjoy this issue.



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

Special Edition

The Dimensions of Geoscience Outreach in Canada



A Tribute to E.R. Ward Neale (1923-2008)

September 2009
Septembre 2009

VOLUME 36 NUMBER 3
VOLUME 36 NUMÉRO 3

Publisher/Éditeur
Geological Association of Canada
c/o Department of Earth Sciences
Memorial University of Newfoundland
St. John's NL Canada A1B 3X5
Tel: (709) 737-7660
Fax: (709) 737-2532
gacpub@mun.ca
gac@mun.ca
www.gac.ca

ISSN 0315-0941/03

Volume 36 Number 3

A journal published quarterly by the Geological Association of Canada, incorporating the Proceedings.
Une revue trimestrielle publiée par l'Association géologique du Canada et qui en diffuse les actes.

Subscriptions: Receiving four issues of Geoscience Canada per year is one of the benefits of being a GAC® member. A subscription is $150.00 per year or $40.00 per single copy.

Abonnement: Recevoir quatre numéros par année du magazine Geoscience est l'un des avantages réservés aux membres de l'AGC®. Le coût de l'abonnement est de 150,00 $ par année ou 40 $ par copie.

We acknowledge the assistance of the Government of Canada, through the Publications Assistance Program (PAP), toward our mailing costs.

Canada

PAP Registration No. 9447
Publications Mail Registration No. 40028338
Postage paid at Ottawa, Ontario/Port payé à Ottawa (Ontario).
Postmaster: Please send change of address/Maître de poste : faire suivre svp.

Those wishing to submit material for publication in Geoscience Canada should refer to the Instructions to Authors on the GAC® Web site, www.gac.ca

Cover. Front cover photo courtesy of Alan Morgan.

EDITORIAL

This 'Ward Neale tribute issue' on geoscience outreach in Canada was first suggested (by Christy Vodden, I believe) not long after Ward's passing in spring of 2008, as a fitting tribute to Ward's career and his commitment to geoscience education. Outreach is a subject that every geoscience society has, over the last 10 to 20 years, made a commitment toward, or even declared as a priority, recognizing that an increased understanding by the general public of the importance of geoscience in their daily lives will ultimately benefit all fields of our profession. With this special issue, *Geoscience Canada* acknowledges the importance of this topic by publicizing some of the great variety of activities that fall under the outreach umbrella, and the individuals and groups that are largely responsible for these efforts in Canada.

Ward Neale was a champion of educating the public about geology before it was called 'geoscience outreach', and for many years he had relatively little company with whom to share his enthusiasm. The reader may learn the details of Ward's seminal contributions in the introductory article by Godfrey Nowlan; suffice it to say here that the example set by Ward is carried forward today by members of the Canadian Geoscience Education Network (CGEN), now the 'outreach arm' of the Canadian Federation of Earth Sciences. CGEN is a thriving organization of dedicated and resourceful volunteer geoscientists (see the article by Christy Vodden), whose members are responsible for virtually all of the contributions to this issue.

It is not often that an editor has the pleasure of dealing with an all-star cast of authors such as those presented herein. I have especially benefited from the very active participation of Fran Haidl, *Geoscience Canada* Associate Editor for outreach matters, who contributed mightily to this project, and Al Donaldson, Assistant Editor for our relatively new series on Geoheritage (see *Geoscience Canada* Vol. 35, No. 2). Some of the contributions appearing here were originally submitted specifically for our geoheritage series (and are noted as such); however, geoheritage is clearly an aspect of outreach and those articles are a good fit within the context of this issue. In addition to Fran and Al, thanks are extended to Christy Vodden and to Eileen Van der Flier-Keller for their assistance in seeing this project to completion. Significantly, Fran, Christy, Eileen, and three other contributors to this issue (Dixon Edwards, Peter Russell, and Godfrey Nowlan) are all former winners of the GAC's E.R. Ward Neale Medal.

Unfortunately, the journal is unable to accommodate, in a single issue, all of the manuscripts that have been submitted for our 'outreach edition'; two articles have therefore been deferred to a later time. I extend my apologies to these authors for the postponement, and the reader may look forward to Scott Swinden's article on the Canadian Geological Foundation, and Randy Miller's article on 'Geoscience Heritage in New Brunswick', in upcoming issues of *Geoscience Canada*. Lest further remarks on my part force the postponement of yet another article, I will close this brief editorial and allow the reader to discover the people and organizations behind geoscience outreach in our country. To conclude, I will add that all of the articles in this issue will be made available for free download on the GAC® website, so that non-GAC® members, teachers, students, etc., can take advantage of some of the ideas and resources discussed in this issue.

Reginald A. Wilson

ARTICLE

The Contribution of Ward Neale to the Development of Scientific Outreach and Education in Canada

Godfrey S. Nowlan
Geological Survey of Canada
3303 – 33rd Street N.W.
Calgary, Alberta, T2L 2A7
E-mail: gnowlan@nrcan.gc.ca

INTRODUCTION

Ernest Richard Ward Neale (1923-2008) was simply "Ward" to all those who knew him. He was a major contributor to the development and well being of the earth science community in Canada. He made contributions to research, especially in the Appalachian orogen, to earth-science education, scientific editing, earth-science societies (he served as President of GAC in 1972-73), and to science outreach. It is his contribution to this last item that is the subject of this brief article.

I am not sure when Ward first got fired up about the importance of science outreach in Canada, but I suspect it might have been when he read the article entitled, *Geology in the Public Eye* (Baird 1968) which was published in a Royal Society of Canada volume that he edited. The final sentence of that article read as follows: "*Our professional societies should seriously appraise our public image, think about what should be done to improve it, and get busy*". Ward took this exhortation to heart and got to work as soon as he took up the position of Head of the Geology Department at Memorial University of Newfoundland (MUN) in 1968. In his early years at MUN he was well known because he did a series of 30 broadcasts for CBC Radio on earth science and another five on Newfoundland geology for the University of the Air series that ran on CTV.

I first met Ward in 1971 as an incoming graduate student to the Department of Geology at MUN, where Ward was still Head. He was very good at communicating messages to others and getting them to buy into his ideas and interests. I know that he had built a magnificent department in which the free, full and frank exchange of ideas was encouraged. Not only was the department a great place to be, but Ward had convinced the university administration that this was the best geology department in Canada. This ability to communicate his ideas and persuade and influence people was a key facet of his character that he applied to science outreach (Fig. 1).

Starting in 1975, he was also a major contributor to this journal in a column called *Pyroclasts,* which put forward, "*news and comment on some of the peripheral matters of interest to Canadian geoscientists, for example, politics and politicians, sex, relations with sister societies, assorted scuttle-butt and rife humour*" (Neale 1975). This column tackled many of the issues of the day and commonly provoked sharp responses, but it served to stir the pot and keep communication going among Canadian earth scientists on the issues of the day. He maintained this effort until the end of 1982, producing a total of 22 *Pyroclasts* columns.

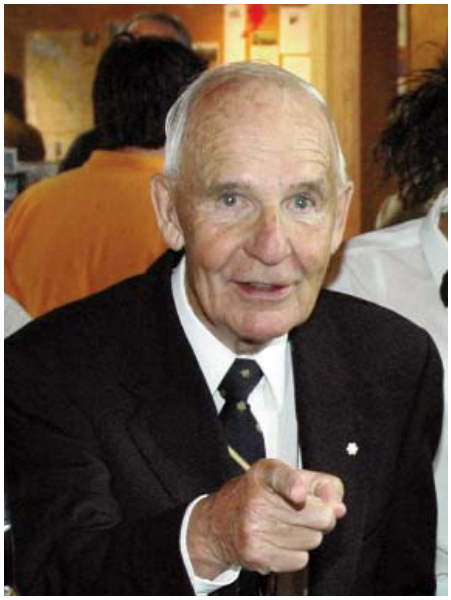


Figure 1. The ever persuasive Ward Neale makes a point at a science fair in Calgary, circa 2004 (photographer not known; supplied by Ward Neale).

THE CALGARY SCIENCE NETWORK

It was when Ward retired in 1987 from his position as Vice-President Academic of MUN and returned to Calgary that his efforts in the public awareness of science kicked into high gear. In Calgary he worked at both the local and national level to achieve multiple goals in promoting the public awareness of science. In 1988, the rudiments of the Calgary Science Network were coming to life in the form of a classroom visit program, and discussions on how to get a city-wide organization that embraced all of science established and funded. Ward was a key instigator and organizer of these activities. At the same time, he was working for the Royal Society of Canada (RSC),

Figure 2. A. Cover of the report compiled by Ward Neale following the 1988 Royal Society of Canada Meeting on public awareness of science. B. Cover of the report by Spurgeon (1990) following the 1990 Royal Society of Canada meeting on the public awareness of science.

to organize a two-day conference of delegates of national scientific and engineering societies that was held in Ottawa on March 4 and 5, 1988 (Fig. 2A). The conference was based on the idea that "*individual scientists can be motivated by their societies to view their work in its social context and to recognize their obligations to explain it to the public*" (Neale 1988). This conference drew together 75 scientists from many different fields and was the first time that many of the representatives were exposed to the outreach activities of scientific and engineering societies in Canada. It served as a stimulant to the development of many new science outreach projects in Canada. Happily, it was also a time when federal programs were designed to increase Canada's science and technology base. Some will remember fondly the Science Culture Canada Program that issued $5 million in grants under a peer adjudicated system. This was a time when there was federal money available for science outreach projects.

A follow-up conference was organized for 1990 by Ward and others. In my recollection this was an even more stirring event, with about 90 scientists and engineers attending; it has been described in some detail by Spurgeon (1990; Fig. 2B). At about the same time, a major study of science literacy in Canada was published (Einsiedel 1990). Edna Einsiedel shared her results at the conference and made a very significant impact. Ward was particularly influenced by this piece of work and it formed the basis for his re-doubled efforts in the following years. In a quote attributed to Ward by Spurgeon (1990), he stated that "*In the two years between conferences, many scientists seem to have realized the need to communicate with the public and are doing so either individually or in ad hoc groups*". He is quoted as pointing out that institutions and societies were slower to heed the call and slow to recognize the efforts of their staff and members. He concluded by saying that, "*It appears the foot soldiers are setting the pace and the leaders must make an effort to catch up with their troops by recognizing changing times and the changing needs of their members and the public*".

These conferences inspired many projects in the public awareness of science across the land. Back home in Calgary, Ward was busy putting the final touches to the Calgary Science Network and it formally became a charitable society in 1991. It had been active in the early days of National Science and Technology Week (NSTW) in 1990, and NSTW was the cement that glued the organization together in the early days. As far as Ward was concerned this was a new paradigm: science outreach from the community's grass roots. Over time he lost faith in the scientific societies that he tried to engage with the RSC conferences and turned to advocating a grassroots approach. The development of the Calgary Science Network in its first decade is well described by Nowlan and Neale (2000). Happily, it has successfully made the crucial transition as a non-profit organization to a board that contains none of its original founders. The organization is now part of a provincial organization, the Alberta Science Literacy Association, and it continues to send scientists to classrooms and to educate teachers through workshops provided jointly by scientists and teachers. Hundreds of thousands of Calgary-area school children have received a visit from a scientist dispatched by the Network (the total of 250 000 was passed in 2009) and nearly 5000 teachers from Calgary and the surrounding area have benefited from a workshop over the last ten years. The network continues to innovate and attract new volunteers, and last year it established a Volunteer Award in Ward's name. I feel sure that CSN was one of Ward's proudest achievements: he did a huge amount of the hard work required to establish such an organization and with typical humility, was proud to be the "first Past President" – he was never President. Over the years he worked tirelessly behind the scenes to attract new people, develop new programs and help sustain existing ones (Fig. 3). It was only when his hearing deteriorated late in his life that he stopped participating actively in the meetings of the network.

THE CANADIAN GEOSCIENCE EDUCATION NETWORK (CGEN)

Ward was also a participant in the conference organized by the Geological Society of America (GSA) from which sprang the Coalition for Earth Science Education (CESE) in 1993. This was held in February at the Johnson Foundation's Wingspread Conference Centre in Racine, Wisconsin. Ward's report from this meeting included a reference to Canada: he noted that, "*we have done a few good things in geoscience education but*

Figure 3. Ward Neale interacting with a child during a "mall science" event run by the Calgary Science Network, circa 1998 (photographer unknown).

Figure 4. Cover of the booklet by Ward Neale and Louisa Horne on how to get involved in science outreach.

they have been generally ad hoc and short-lived, the EdGEO program of the Canadian Geoscience Council is a partial exception. It is time to take a leaf out of the book opened by GSA and either join the coalition it is bringing together or form a separate Canadian coalition with links to that of our US colleagues". This was a clear reference to the concept of the Canadian Geoscience Education Board, which held its first meeting in May 1993.

Inspired by the Wingspread meeting and the model of CESE, Ward played a key role in the development of what was called the Canadian Geoscience Education Board. Again he cajoled people to get involved and he promoted the idea for what was to become one of Canada's most successful groups in the public awareness of science. The inaugural meeting of this organization was held on Wednesday May 19, 1993, in Edmonton, in association with the GAC–MAC meeting held there. Again Ward was not the Chair – that honour fell to Laing Ferguson (then of Mount Allison University) – but Ward had played a strong role in advocating for the formation of the organization. The original composition of the Board was a representative from each earth science society, which was in line with Ward's early thinking on the importance of societies. In late 1994, because of uneven participation from society representatives, it morphed into the Canadian Geoscience Education Network and invited *all* those interested in geoscience outreach to become members. The minutes stated that the word "Board" had an authoritarian ring to it and that the group, "*decidedly wanted to be an activist grassroots organization"*. Thus it followed the shift from society-based function to grassroots function that Ward so favoured.

One of Ward's major contributions to the early efforts of CGEN was the publication of a booklet entitled *A Geoscientists' Guide to Public Awareness of Science and Technology* (Fig. 4). This booklet was co-authored with Louisa Horne and co-published with the Geological Association of Canada (GAC) in May 1995. A free copy of this attractively illustrated booklet was provided to every registrant at the 1995 GAC–MAC meeting in Victoria. It provided helpful advice to anyone who was interested in getting involved in the public awareness of earth science.

CGEN now has more than 300 members and can honestly be said to be the most successful group at getting things done in earth science outreach in Canada. In its early days, it took EdGEO under its wing, and the chair of CGEN became the Outreach Director of Canadian Geoscience Council (CGC) and subsequently the Canadian Federation of Earth Sciences (CFES), thus giving the organization a great opportunity to maintain communication with the earth science community while at the same time reaching out to people all across Canada. It is interesting to note that the organizational trajectories of CGEN and CESE have turned out quite differently. The CESE represents a diverse group of organizations and individuals dedicated to addressing national concerns in Earth system education, and was instrumental in getting earth science incorporated into the National Science Education Standards in the United States, providing opportunity for nationwide implementation of earth science into school science curricula, although I think our US colleagues would agree that there has not been universal success with this approach. The CGEN took a more grassroots approach and at the recent (2009) Joint Assembly meeting held in Toronto, I heard several American outreach people say that they needed the

kind of network provided by CGEN. On the other side of the coin, CGEN is only now getting around to addressing earth science in curricula and it is using a rather different approach, i.e. encouraging the use of earth science examples in the social studies and science curricula.

AWARDS AND ACCOLADES

Ward was appointed to the Order of Canada on April 20, 1990. He was recognized as a scientist and university administrator, but one sentence from the citation also recognized his contribution to earth science outreach: "*he has made a significant contribution to the public appreciation of science and to the international geoscience community*". This award meant a lot to Ward and I think he was particularly gratified that his contribution to outreach was recognized.

The Geological Association of Canada struck a medal in 1995 in Ward Neale's honour (Fig. 5). The description of the qualities of a winner of the medal is as follows: "*The award recognizes outstanding efforts to communicate and explain geoscience to the public through one or more of the following vehicles: public lectures, print or electronic media articles, school visits, elementary and secondary school educational materials, field trips, science fairs, and other public communications*". In fact the description of the E.R.W. Neale Medal cites him as "*the legendary Ward Neale*", indicating the great respect and affection in which he was held by the membership of the GAC. I think, perhaps, this recognition even eclipsed the pleasure he felt upon receiving the Order of Canada and he made sure that he and his wife Roxie were at every award ceremony for this medal from 1995 to 2007, passing away just before the 2008 ceremony. He was always careful not to endorse any particular candidate for this award and was delighted every year to discover who would be the latest addition to the list of Neale medal winners.

CONCLUDING COMMENTS

Ward continued as an activist for the Calgary Science Network and other organizations throughout the late 1990s and into the twenty first century. He volunteered at all sorts of events, including science fairs, and was always part of the contingent that went to aboriginal science fairs in southern Alberta. In his later years, Ward became hard of hearing and was never satisfied with hearing aids, despite investing in a variety of devices. His inability to hear well drove him to abandon most meetings and thus separated him from the formal processes of many of the organizations for which he had worked so hard throughout his life.

Figure 5. The E.R.W. Neale Medal of the Geological Association of Canada (courtesy of GAC®).

The last major earth science outreach meeting that he attended was the session and workshop held in conjunction with the 2007 GAC–MAC in Yellowknife, NWT. He was enormously pleased with the fact that the largest session at the meeting was the Outreach session and that he was there when the E.R.W. Neale Medal for 2007 was awarded to Dixon Edwards. The outcomes from that meeting (Nowlan and Schreiner 2007) bore the stamp of Ward's contributions.

Ward would be delighted with the new developments in the area of Geoheritage in Canada. The fact that there is an active national group under the leadership of Al Donaldson and a strong groundswell for the establishment of GeoParks in Canada would be music to Ward's ears.

The contribution of Ward Neale to the development of modern science outreach programs in Canada is immense. He was behind the scenes of almost every major innovation in science outreach in Canada since the late 1980s. He was a constant gadfly, coaxing and cajoling fellow scientists to explain what they did in terms the public could understand. At the same time he was a walking job jar who persuaded many individuals to pull a job out of the jar and get working on it. His tremendous persistence, coupled with his innate charm, produced many of the current leaders in science outreach in Canada, especially in the earth sciences. The fact that there are now 300 people in Canada pleased to receive regular notifications and news from the Canadian Geoscience Education Network is a testament to his energy and vitality, which never waned up to the day he died.

REFERENCES

Baird, D.M., 1968, Geology in the Public Eye, *In* The Earth Sciences in Canada: A Centennial Appraisal and Forecast, *edited by* E.R.W. Neale: The Royal Society of Canada, Special Publication No. 11, p. 222-230.

Einsiedel, E.F., 1990, Scientific Literacy – A Survey of Adult Canadians: Commincations Studies, University of Calgary, 50 p.

Neale, E.R.W. 1975, A Column: Geoscience Canada, v. 2, p. 220-221.

Neale, E.R.W., 1988, [Compiler] Science and the Public, Report on a conference of National Scientific and Engineering representatives: Royal Society of Canada, 23 p.

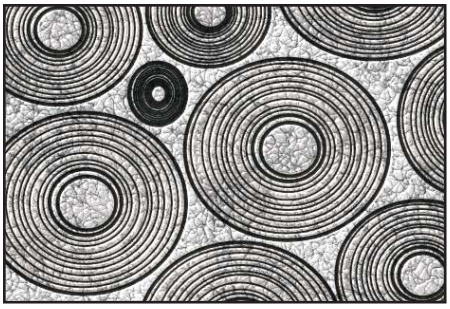
Neale, E.R.W., and Horne, L., 1995, The PAST is the Key to the Future: A Geoscientits' Guide to Public Awareness of Science and Technology: Geological Association of Canada and the Canadian Geoscience Education Network, 28 p.

Nowlan, G.S., and Neale, E.R.W., 2000, Evolution of the Calgary Science Network: An unabashed tale of speciation, extinction and diversity: Geoscience Canada, v. 27, p. 23-30.

Nowlan, G.S., and Schreiner, D., 2007, The State of Earth Science Outreach in Canada and an Action Plan for the Future: Results of a Session and Workshop Held in Yellowknife, N.W.T., May 24-27, 2007: Geoscience Canada, v. 34: 49-54.

Spurgeon, D., 1990, Communicating Science: Why and How, Second conference on public awareness of science in Canada: Royal Society of Canada, 22 p.

SERIES



Geoheritage 2. Examples of Geoeducation, Geoconservation and Georescue Projects in Ontario

J. Allan Donaldson
Adjunct Research Professor
Department of Earth Sciences
Carleton University
Ottawa, ON, Canada, K1S 5B6
E-mail: donaldson6427@rogers.com

SUMMARY

Three case studies presented here outline the progress of projects recently initiated to improve public appreciation of the diversity, complexity and significance of Earth history, with an emphasis on the importance of such knowledge to humanity. Work on two of these projects has highlighted the paucity of legal protection for significant geological records as well as the frequent loss of basic geoscience data during construction-related landscape modification. These three case studies in promoting geoheritage awareness and geoconservation reinforce the need for the Canadian geoscience community to seek improved legal instruments for the protection of sites of geological and geomorphological importance, and to seek improved procedures for the documentation of information that too commonly is irretrievably lost during major construction projects.

SOMMAIRE

Les trois études de cas présentées ci-dessous, permettent d'illustrer les progrès de projets récents visant à améliorer l'appréciation du public des notions de diversité, de complexité et des conséquences de l'histoire de la Terre, en insistant sur l'importance de ce savoir pour l'humanité. Le travail réalisé dans deux de ces projets a fait ressortir le manque de protection légale des archives géologiques d'importance ainsi que la perte fréquente de données géoscientifiques de base lors de travaux de construction altérant le paysage. En faisant la promotion de la sensibilisation à l'héritage géoscientifique et à sa conservation, ces trois projets renforcent la nécessité faite à la communauté géoscientifique canadienne de rechercher de meilleurs instruments légaux de protection des sites géologiques et géomorphologiques d'importance, et de rechercher de meilleurs procédures de documentation de l'information, laquelle est trop souvent irrémédiablement perdue à l'occasion de grands projets de construction.

INTRODUCTION

Many European countries, Australia and China have developed extensive programs for geoheritage education, and, in general, are well ahead of Canada in recognizing and celebrating their geodiversity (Gray 2004), but groups concerned with geoscience education, such as the Canadian Geoscience Education Network (CGEN), are working to diminish the gap, with numerous projects now underway (Nowlan 2007). The Ottawa–Gatineau Geoheritage Project, initiated in 2002 and adopted as a new initiative by CGEN in 2003 [http://cgen.bio.ns.ca/cgen-noteaug03.pdf], has been active in this regard through the provision of public talks, poster displays and field excursions (Donaldson 2003, 2005, 2006; Donaldson and Aylsworth 2004). In response to local interest, a complementary project was started in 2003 in Almonte Ward of Mississippi Mills, 55 km west of Ottawa. The Almonte Geoheritage Project follows the success of similar earlier projects in Waterloo (Peter Russell Rock Garden, University of Waterloo [http://www.earth.uwaterloo.ca/services/rockgarden]), in Regina (GEOrock Garden), in Haileybury at the Haileybury School of Mines [www.rockwalkpark.com], and in St. John's (The Johnson GEO CENTRE and associated GEOPark [http://www.geocentre.ca/]). The rock display now being assembled in Almonte will be given the name 'Metcalfe Geoheritage Park' when officially opened in May 2010, making it the first municipal rock display to include 'Geoheritage' in the official name of the display site. This display is being assembled entirely through volunteer contributions of rock specimens and transport.

Geoconservation presently receives little or no consideration in Canada during construction projects and the creation/expansion of roads. Where rock outcrops or unconsolidated deposits stand in the way of proposed construction, both rock and overburden almost invariably are regarded as obstacles to be removed, with little or no consideration of the possibility that these landscape elements contain unique, distinctive or representative records of our biotic

and/or abiotic past. Except for Canada's National and Provincial Parks and our World Heritage Sites, legislative protection is for the most part non-existent. Although some provinces do offer limited recognition and protection, in practice most relevant laws are either not enforced or lack substantial clout to be effective. Québec offers the most advanced provincial geoheritage protection, and the three Territories provide legislative protection above the provincial level. In Ontario, designation as an Area of Natural Scientific Interest provides nominal protection against destruction, but some such sites have already been degraded or destroyed. When a new feature of potential significance is uncovered as a result of commercial excavation or road building anywhere in Canada, only rarely are formal procedures put in place to document the information revealed as construction proceeds, let alone afford protection. Geoconservation receives much greater attention in other countries (see the mandate of the GeoConservation Commission in the UK [www.geoconservation.com]).

The three case studies presented here are;

1. Metcalfe Geoheritage Park
2. Biofilm Structures in the Cambro-Ordovician Napean Formation
3. Megastromatolites in Almonte

CASE STUDIES

Metcalfe Geoheritage Park

In June 2008, members of Mississippi Mills Council (MMC) in Eastern Ontario, unanimously endorsed a proposal to create within Metcalfe Park, an existing park in Almonte (a Ward of about 4400 inhabitants within Mississippi Mills, 55 km west of Ottawa), a display of large blocks and boulders representative of local geodiversity. They further approved the renaming of this park 'Metcalfe Geoheritage Park' with an official opening ceremony scheduled for May 2010. In 2003, as an initiative of the Almonte Geoheritage Project (in collaboration with the Ottawa–Gatineau Geoheritage Project), the creation of a geological display in Metcalfe Park was first proposed to MMC. Neil Carleton of the Almonte Geoheritage Working Group contacted relatives of Dr. Metcalfe, a prominent early resident of Almonte, and received their endorsement for geoheritage park designation. Plans evolved during subsequent meetings with members of MMC, and support was obtained from other organizations, including the Mississippi Mills Chamber of Commerce (MMCC) and the Mississippi Valley Field Naturalists (MVFN). Enthusiastic endorsement by all Council members, MMCC, MVFN and many relatives of Dr. Metcalfe (after whom the park was named; he was not only a renowned medical doctor, but also founded the local hydro facility within Almonte), have served to ensure successful development of an outdoor attraction that will provide an ideal setting for educating both local citizens and visitors about Canada's geoheritage. Several self-guided field excursions have been designed to amplify what can be learned from the Metcalfe Geoheritage Park rock display, and a brochure containing this information will be available at the Almonte Visitors Centre, along with another brochure that will provide information about the rocks on display in Metcalfe Geoheritage Park.

Plans have been drawn up to accommodate 30 large specimens selected to display rock types, textures, structures and fossils. Nine specimens are now in place; 15 more have been selected and await transport and placement (Fig. 1). A recent appeal for additional specimens elicited numerous offers of donations from farms and rocky woodlots of MVFN members. Local construction companies have offered free removal, transport and placement of the selected contributions. The Metcalfe Geoheritage Park Project has gained substantial publicity through the Almonte *Gazette* and other local publications, greatly accelerating an awakening of interest in geoheritage. Don Wiles, a resident of Almonte and a Carleton University Professor Emeritus (Chemistry) has initiated the Learning in Almonte Series, a new program of educational lectures in collaboration with Carleton University. One of the first of the lecture series comprised six two-hour sessions on geoheritage, plus three local excursions to explore local geoheritage. Almonte has a fascinating history, and boasts numerous beautiful stone buildings. It has been satisfying to see how an extension of history from centuries to eons has come so readily to Almonte inhabitants.

Figure 1. Selection of first block for display in Metcalfe Geoheritage Park in Almonte, Ontario. Project Working Group members present are Neil Carleton (left) and Ben Cleland.

Stromatolites and Biofilm Structures on Highway 417

Outcrops of Cambro-Ordovician Nepean Formation are exposed along both sides and within the median strip of the Queensway (Highway 417) in the Kanata suburb of Ottawa. Reports of soft-sediment deformation in outcrops of these strata immediately east of Terry Fox Drive led to Province of Ontario designation as an Area of Natural Scientific Interest (ANSI) in 1970. Such designation provides one of the few protective measures available for geologically significant sites outside Provincial Parks in Ontario. Re-examination in 2000 of these outcrops (Hilowle et al. 2000) resulted in recognition of the first-reported occurrences in Canada of quartz arenite containing stromatolites and biofilm structures (Fig. 2), thus greatly enhancing the ANSI significance of these outcrops. Subsequent research has confirmed the significance of this occurrence of siliciclastic stromatolites (Donaldson and Hilowle 2002, Donaldson et al. 2002, Donaldson et al. 2005a, b).

As a consequence of work commenced during the summer of 2008 to add lanes to the Queensway, all outcrops within the median at the Terry Fox ANSI site will be destroyed to provide space for two new lanes. On becoming aware of this planned highway widening the author, on behalf of Friends of Canadian Geoheritage (an organization sponsored by Canadian Geoscience Education Network), contacted key officials of the Ontario Ministry of Transport, Ontario Parks and Ontario Ministry of Environment. In a meeting with these officials in 2003, a 'geosalvage operation' was deemed feasible, subject to expression of interest from museums, universities and other organizations in securing blocks for public display. Representatives of Waterloo University, Carleton University, University of Ottawa, St. Lawrence University, Canadian Museum of Civilization, and the Town of Mississippi Mills all indicated interest in receiving one large specimen each from this site. With interest thus established, approval was granted for removal of up to 10 large blocks by jackhammer and hand-operated pry bars, rather than by blasting the rock.

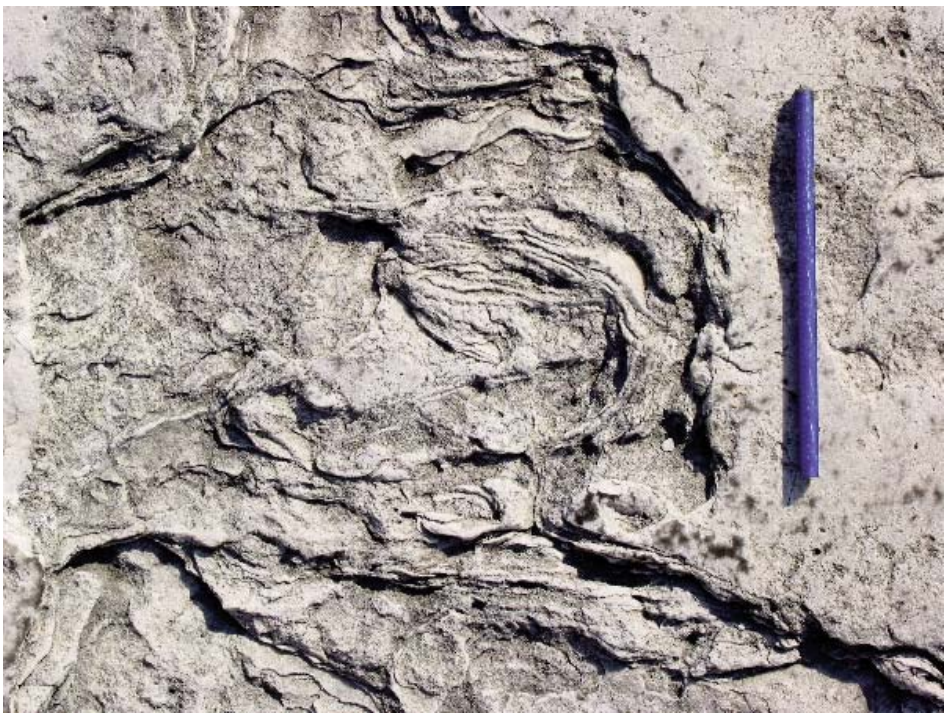


Figure 2. Biofilm structures in quartz arenite of the Nepean Formation showing a bedding-parallel view of crumpled sheets of quartz sand. These layers are inferred to have been bound by cyanobacterial mats between the sand layers, now degraded to carbonaceous wisps. The site on Highway 417 at Terry Fox Drive in Ottawa is a designated Ontario Area of Natural Scientific Interest.

Recovery of these specimens will provide display material to illustrate structures documenting the role of cyanobacterial biofilm sheets in binding sand layers to create roll-up and desiccation structures in siliciclastic sand within an Ordovician intertidal environment. Had recent research not established the rarity of such distinctive structures, and Ontario Parks and Environment officials not been alerted to the pending road work, the outcrops containing these structures within the median of Highway 417 would have been completely destroyed, despite their ANSI designation.

Megastromatolites in Almonte

With a heightened awareness of geoheritage values stimulated by his work on the Metcalfe Geoheritage Park Project, Neil Carleton (Geography teacher, R. Tait McKenzie Public School in Almonte) immediately recognized the significance of a bedrock surface uncovered, in September 2008, within a block of his residence. The exposure was created during the start of development of a site for erection of a cluster of townhouses. Removal of a one-to-two-metre cover of Leda clay had revealed a unit of dolostone in the Paleozoic Oxford Formation replete with laterally linked domal stromatolites, some up to 4 m in diameter, with synoptic reliefs up to 60 cm (Fig. 3). Realizing that this exposure may present the best display of distinctive megastromatolites within an urban area anywhere in Canada, the developers were contacted to see if they would be amenable to preserving at least a small segment of this remarkable but potentially ephemeral exposure. It has the distinction of being the uppermost unit in the Oxford Formation, with relict patches of the overlying Rockliffe sandstone preserved in several places at the top of the presently exposed area. Because there is no legislative recourse to obtain protection of newly uncovered geoheritage sites such as this one, preservation of a part of it hinges on the good will of the developers. Fortunately, the site developers are amenable to the possibility of preserving a small area containing several of the largest stromatolites. Depending on what accommodations can be provided to the developers (e.g. possible

Figure 3. Overview of giant domal stromatolites in dolostone of the Oxford Formation; Ann Street Townhouse Development, Almonte, Ontario.

tax reduction and/or financial compensation for withdrawal of several townhouse lots from the planned development), there is reason to hope that a representative segment may be saved. Organizations that may offer assistance have been contacted (MMC, MVFN and Nature Conservancy of Canada); in the meantime, the ongoing operation continues to degrade the stromatolitic unit by mechanical fracturing and excavation.

LESSONS PROVIDED BY THESE CASE STUDIES OF GEOHERITAGE-RELATED PROJECTS

The Metcalfe Geoheritage Park project provides a case study of how easily the public can be made aware of the importance of their geoheritage, and will soon offer a new setting for geoeducation via a varied outdoor display. Such displays, as previously mentioned, have been created elsewhere in Canada (Waterloo, Haileybury, Regina, and St. John's), but the new rock display in Almonte is the first to be designated as a municipal Geoheritage Park in Canada – and perhaps in the world. The geoscience-awareness potential of such displays is tremendous. By simply initiating such a project, not only can a greater appreciation of the importance of geoheritage be swiftly established, but considerable goodwill can be generated for the geoscience community.

The Highway 417 and Almonte megastromatolite projects have both revealed the need for legislation to better protect geological wonders. Although we have been successful, so far, in gaining support for the preservation of representative specimens of biofilm structures in siliciclastic sandstone along Highway 417 that would otherwise be destroyed, and have found possible avenues for preserving a part of an outstanding new exposure of megastromatolites in Almonte, there are many instances of significant and unique geological treasures being completely destroyed. The type locality for perthite, for instance, now lies buried beneath a highway in Ontario. Why should not geoheritage sites be afforded protection at least to the level now provided for archaeological sites? A concerted move by the geoscience community to bring about appropriate legislation is long overdue. In Australia, their national Heritage Commission has drawn up a Natural Heritage Charter (Australian Heritage Commission 2002), and Britain has an active Nature Conservancy Council (Attenborough 1990) that works to protect values inherent in the abiotic world. These organizations can serve as models for the geoscience community to promote the adoption of substantive geoconservation measures in Canada.

Astoundingly, even where road building and construction threaten unique features in most parts of Canada, little to no effort is expended to record data from ephemerally exposed sections. Where such information is obtained, it is generally due to serendipitous observations by geoscientists who keep tabs on local projects, or simply fortuitously spot features of interest in a new road-cut or construction site. As public support of the geosciences is nurtured through the provision of appropriate programs to increase public awareness of things geological, we can expect that additional features of interest will be brought to the attention of geoscientists. The provision of seminars on local geology and geomorphology to workers who operate rock-smashing and earth-moving machines could enhance such feedback. The bottom line is that our extraordinary geoheritage must be more widely promoted to all segments of the Canadian public.

ACKNOWLEDGEMENTS

Neil Carleton of Tait McKenzie Public School in Almonte has been an essential member of our Metcalfe Geoheritage Park Working Group. Ben Cleland of Almonte, who went on to obtain a degree in Geology from Carleton University, worked untiringly with us as a volunteer during the summer of 2003, the first year of our evolving initiative to introduce the geoheritage concept to Almonte. Kelly Currie and Julie Argue of Mississippi Mills Chamber of Commerce have graciously displayed our posters and distributed our pamphlets in the Almonte Visitors Centre. Mayor Al Lunney, and all Mississippi Mills Councillors have been supportive of our efforts. Calvin Murphy, in charge of the Mississippi Mills Parks and Recreation Committee provided liaison and advice throughout 2008. Cliff Bennett, President of MVFN, has been extremely helpful in advancing the project, as have members of his very active and scientifically astute group, including Pat Browne, who has provided much useful information about the megastromatolite

site. Patricia Larkin of Nature Works Learning has provided liaison in organizing the movement of selected rock specimens to Metcalfe Geoheritage Park. Scott Newton of Mississippi River Power Corp. provided access to rock cuts recently created for the hydro plant in Almonte, from which several rock slabs have been selected for display in Metcalfe Geoheritage Park. Sullivan and Son Construction, Karson Group, Cavanaugh Construction, and Oliver Toop have provided rock specimen transport. Developers Adrian Shouten and Andrew Cinnamon of Parkview Homes met us on site to discuss possible preservation of a part of the recently exposed megastromatolite unit within the Ann Street subdivision. Phil Kor of Ontario Parks and Ewa Bednarczuk of the Ontario Ministry of the Environment were key players in arranging the Highway 417 georescue operation. Christy Vodden's review of this paper provided many excellent suggestions for improvement.

REFERENCES

Attenborough, D., 1990, Earth Science Conservation in Britain: A Strategy: Nature Conservancy Council, Peterborough, UK, 84 p.

Australian Heritage Commission, 2002, Australian Natural Heritage Charter, Second Edition, Canberra, Australia, 25 p.

Donaldson, J.A., 2006, Friends of Canadian Geoheritage and the Ottawa-Gatineau Geoheritage Project: Where do we go from here? GAC–MAC, Montreal 2006, Program with Abstracts, p. 40.

Donaldson, J.A., 2003, Promoting geoscience through collaboration: The Ottawa-Gatineau geoheritage project: Geoscience Education Conference IV, Geoscience Education for the Global Community, Calgary, Proceedings, 4.

Donaldson, J.A., 2005, Friends of Canadian Geoheritage: A progress report: GSA Annual Meeting, Salt Lake City, [http://gsa.confex.com/gsa/2005AM/finalprogram/abstract_92224.htm.]

Donaldson, J.A., and Aylsworth, J.M., 2004, Expanding geoscience awareness through Friends of Canadian Geoheritage: GAC–[MAC, St. Catherine's 2004, Program with Abstracts, [http://gac.esd.mun.ca/gac_2004/search_abs/sub_program.asp?sess=98&form=10&abs_no=151.]

Donaldson, A., and Hilowle, M.A., 2002, Organic mats, evaporite pseudomorphs and soft-sediment deformation in quartz arenites of the Cambro-Ordovician Nepean Formation: GAC–MAC, Saskatoon 2002, Program with Abstracts, [http://gac.esd.mun.ca/gac_2002/search_abs/sub_program.asp?sess=98&form=10&abs_no=73]

Donaldson, J.A., Munro, I., and Hilowle, M.A., 2002, Biofilm structures, trace fossils and stromatolites in Early Paleozoic quartz arenites and carbonates of the Ottawa region, Ontario: Twelfth Canadian Paleontology Conference, Program and Abstracts, 12.

Donaldson, J.A., Chiarenzelli, J.R., and Aspler, L.B., 2005a, Cambro-Ordovician stromatolite occurrences in the Ottawa region: Geological Society of America, Northeastern Section, 40th Annual Meeting, Saratoga Springs, NY, paper No. 3-3, [http://gsa.confex.com/gsa/2005NE/finalprogram/index.html.]

Donaldson, J.A., Chiarenzelli, J.R., and Aspler, L.B., 2005b, Siliciclastic stromatolites and biofilm structures: Conditions for preservation: GAC–MAC–CSPG–CSSS Halifax 2005, Abstracts, p. 45-46.

Gray, M., 2004, Geodiversity: valuing and conserving abiotic nature: Wiley, 434 p.

Hilowle, M.A., Donaldson, J.A., Arnott, R.W.C., 2000, Biofilm-mediated structures in quartz arenites of the Cambro-Ordovician Nepean Formation. GeoCanada2000 – The Millenium Geoscience Summit, Calgary, conference CD, [www.ironleaf.com, abstract 868.]

Nowlan, G.S., and Schreiner, D., 2007, The state of earth science outreach in Canada and an action plan for the future: Results of a session and workshop held in Yellowknife, NWT, May 24-27, 2007: Geoscience Canada, 34, p. 49-54.

SERIES

Geoheritage 3. Attracting Students to the Earth Sciences: An Example of Individual and Collective Outreach Efforts by Industry, Academia and Secondary Education

Charly Bank
Department of Geology
University of Toronto
22 Russell Street
Toronto, ON, Canada, M5S 3B1
E-mail: bank@geology.utoronto.ca

Deryk Jackson
Danforth Collegiate and Technical Institute
800 Greenwood Ave.
Toronto, ON, Canada, M4J 4B7
E-mail: deryk.jackson@tel.tdsb.on.ca

Lesley Hymers
Prospectors and Developers Association of Canada Mining Matters
135 King Street East
Toronto, ON, Canada, M5C 1G6
E-mail: lhymers@pdac.ca

SUMMARY
Too few Canadian high-school students are pursuing post-secondary studies and career opportunities in the earth sciences. Given Canada's wealth of renewable and non-renewable resources and their importance to society, it is imperative that students become literate in the earth sciences, and that they are encouraged to pursue career opportunities in the many fields that constitute the earth sciences. To achieve these goals, a number of outreach efforts by members of industry, academia and secondary education have been initiated. We outline here an example of our own collaboration in one such program directed not only at students, but also at primary and secondary teachers, university faculty, industry representatives and government officials. Our program has achieved significant results, and so will continue. Others interested in increasing the profile of the earth sciences are encouraged to explore such new outreach approaches.

SOMMAIRE
Trop peu d'élèves des écoles secondaires au Canada poursuivent des études en sciences de la Terre et choisissent d'y faire carrière. Étant donné la richesse du Canada en ressources renouvelables et non-renouvelables et leurs importances pour le bien commun, il est absolument essentiel que les élèves acquièrent des connaissances de base en sciences de la Terre et soit encourager à embrasser des carrières dans l'une des nombreuses spécialités du champ des sciences de la Terre. Pour y arriver, un certain nombre d'initiatives de sensibilisation ont été lancées par des membres du secteur industriel, du monde universitaire, et de l'éducation secondaire. Nous décrivons brièvement ci-dessous notre collaboration dans le cadre d'un programme du genre visant non seulement les élèves, mais aussi les enseignants des écoles primaires et secondaires, les membres du corps professoral des universités, les représentants du secteur industriel et ceux des gouvernements. Notre programme a connu des succès importants, et donc il sera maintenu. Nous incitons toute personne intéressée à promouvoir l'image des sciences de la Terre à considérer de telles approches nouvelles.

INTRODUCTION
Earth sciences are crucial for today's society: our cities are threatened by natural disasters, our growing population demands safe drinking water and sustainable waste management, our society requires resources, and our activities are accelerating global climate change. Canadians, in particular, draw prosperity from our country's abundance of natural resources, and feel the negative impacts of global climate change. Job prospects in the earth sciences are, and should remain, excellent, even in times of economic upheaval, because of an anticipated wave of retirement and the continuing need for resources. In our opinion, earth science is not as highly prioritized in Canada's high-school curricula as it should be, perhaps, in part, because of a perception linked to poor mining practices in the past. As a consequence, most high-school graduates do not know enough about earth sciences to explore education possibilities in this exciting field, and therefore few consider it as a career path. Faced with this problem, many earth-science scholars and teachers are now spending a lot of time on geoscience outreach, or sharing their knowledge with the community.

Nowlan and Schreiner (2007) highlighted key themes for outreach efforts in Canada, noting that outreach

has several stakeholders, each contributing in distinct ways to the effort. At the centre of our own outreach activities are the high-school students we want to attract to careers in the earth sciences. Other stakeholders include industry, the Ministry of Education, and the public. How they fall within the context of our outreach program is shown in Figure 1. This article highlights our individual and collaborative efforts to support teachers in their quest to deliver relevant content, to encourage students to think about earth science as a possible career option, and to spur university administration and the Ontario provincial government to increase the profile of earth science.

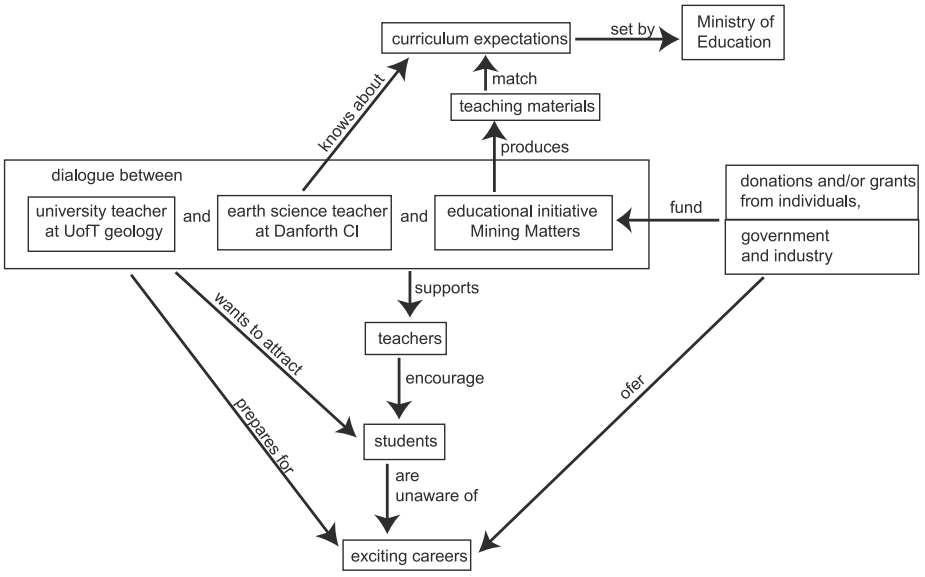


Figure 1: Stakeholders and their connectedness in outreach efforts.

ABOUT US

Toronto and the surrounding area is home to a large population of high-school students, dedicated teachers, well-respected universities, world-class museums, and mining companies trading on the Toronto Stock Exchange. Such a setting is ideal for individuals from various institutions involved in earth-science outreach to collaborate; indeed, the three authors of this article met because of our common involvement. In this section we introduce ourselves and our institutions. Two years ago we started to collaborate because we realized that we can be more effective by sharing in our efforts; however, we do acknowledge that we belong to institutions that follow their own mandates and objectives.

Prospectors and Developers Association of Canada Mining Matters

Mining Matters brings the wonder of Canada's geology and mineral resources to students, educators and industry. Mining Matters is a non-profit organization dedicated to educating students, teachers and industry about the importance of minerals, metals and mining and the role that they play in our daily lives. The organization provides current information about rocks, minerals, metals, and mining and offers exceptional educational resources that meet Junior, Intermediate and Senior provincial Earth Science and Geography curricula expectations, developed by teachers and for teachers.

Since 1994, Mining Matters has utilized these educational resources to introduce Earth Science to more than 400 000 teachers and students. At the time of the program's inception, members of the Prospectors and Developers Association of Canada (PDAC) realized that their mining and mineral industry expertise could be of help to teachers and students. In consultation with experts in education, government, and business, the PDAC developed the first Mining Matters Earth Science curriculum kit for grades 6 and 7 teachers in Ontario.

PDAC Mining Matters became a registered charitable organization in 1997. Since then, Mining Matters has partnered with government, industry, and educators to produce bilingual teaching units for grades 4 and 7, as well as to develop additional teaching materials. In 2007, Mining Matters launched its first unit for high-school educators and added a secondary school newsletter to its list of publications. Since 2002, Mining Matters has been managed under the leadership of Laura Clinton, a former educator at the Ontario Science Centre. Lesley Hymers served as interim manager in 2008-2009; prior to joining the organization, Lesley managed an industry education program for Dufferin Aggregates. Mining Matters is supported by provincial government foundation grants and donations from corporations and individuals. Expert support is provided by external educational consultants, and Geoscience technical experts. In addition to classroom resources, Mining Matters has produced other educational materials including activities, posters, leaflets, and newsletters. Mining Matters also offers workshops for students in elementary and high schools and operates an Aboriginal Youth Outreach Program. Their instructional development workshops for teachers attracted nearly 500 participants in the past year, representing contact with nearly 7000 students. In 2008, Mining Matters expanded its program to Manitoba and British Columbia, and future plans include expanding to additional provinces and territories.

Department of Geology at the University of Toronto

For over 100 years the department has housed world-renowned researchers, graduate students, and undergraduate students. Undergraduate courses taught at the department range from introductory courses (taken by over 1000 students each year) to minor, major, and specialist programs; the latter prepare students for registration as professional geoscientists in the province. Enrollment in the major and specialist programs has nearly doubled in the past three years, likely in response to the booming resource industry. The undergraduate students are keen to help with outreach efforts, which in the past 15 years have been coordinat-

ed by a full-time teaching faculty member (Kathleen Kemp until 2002, Irene Antonenko from 2002 to 2005, and Charly Bank since 2005).

Danforth Collegiate and Technical Institute

This central Toronto high school, with a student population of about 1200, offers a number of pathways for its students to pursue their post-secondary goals. One of the pathways includes a specialized Math, Science and Technology program (called MaST) for interested and highly capable students. Several teachers at Danforth have an interest in Earth Science, including Deryk Jackson, who lobbied for the inclusion of Earth and Space Science among the course selections. This course has been offered for the past 3 years and has seen its enrollment increase from 30 students in the first year to 70 students for the 2009-2010 academic year. David Orenstein, a teacher in Danforth's Math Department, along with one of us (CB), was instrumental in establishing an Earth Science professional development day for teachers in the Toronto District School Board. Now in its third year, this ongoing professional development program is extremely popular among Toronto teachers.

WORKING WITH HIGH-SCHOOL STUDENTS

Young children universally display an interest in earth science; they build sandcastles and dams at the beach, and share a fascination with rocks, minerals and fossils, especially dinosaurs. Unless nurtured, this natural curiosity generally diminishes as they enter adolescence, and by the time they leave high school, few realize that earth science exists as a subject.

Exposing students to practical applications of earth sciences can be achieved by visiting them in schools or inviting them to join excursions. Typically, visits to a school are initiated by a teacher, and require a commitment in time for preparation and travel. Such activities are most effective if they directly link to the curriculum expectations. Apart from show-and-tell about mineral and rock specimens, students can benefit from real world examples, like analyzing earth science data during a math class. Undergraduate and graduate students are often willing to undertake such visits. Taking high-school students on excursions to universities, museums or to field sites requires administrative work by the teacher; however, students get the opportunity to meet scientists in the environment in which they work, visit interesting labs, and gain access to resources (for example, teaching collections and microscopes) that are not available at their schools. Often they get a chance to interact with undergraduate students who can talk to them first hand about their experiences. In the field, students get to ask questions of experts, allowing them to discover how little they know about the world around them.

At the University of Toronto we offer 'Girls Rock Science', a Saturday seminar series attended by female high-school students and facilitated by female university faculty. We offer about eight seminars a year with an average attendance of 20 participants. Many students find out about the series from their teachers or from the university website; the university advertises the series to high schools and provides administrative help. The series was initiated because the university wanted to attract female students into the sciences, and is hosted at the geology department, although faculty from other departments are involved. Female faculty, post-docs, and advanced graduate students cover a wide spectrum of topics (e.g. groundwater remediation, chaos, climate change, metals in the environment) in their presentations, incorporate hands-on activities, and structure their presentations to facilitate discussions. Workshops are small (fewer than 25 participants) to allow for meaningful question-and-answer periods. Participants especially value opportunities for personal interaction, when they can ask professors what it is like to work as a female in the field, and what advice they can give.

Citywide university outreach events provide a venue that we have been able to successfully tap. For example, the University of Toronto opens its doors each year, on one Saturday in October. Known as university Fall Day, during which departments advertise their programs at booths, it attracts thousands of high-school students within a two-hour driving radius. Our experience has been that most students are not interested in geology, but this changes once we engage them in conversation. The university also organizes a one-day conference for gifted high-school students during which individual departments are invited to offer two-hour sessions. In May 2008, Toronto hosted 'Science Rendezvous' during which the Geology Department was full of visitors eager to experience 'The Great Rock Melting Experiment' (Fig. 2).

Figure 2: Undergraduate student Ramona Dasrath demonstrating 'The Great Rock Melting Experiment' in the high temperature lab at the Department of Geology, University of Toronto, during 'Science Rendezvous', a citywide outreach event in May 2008. (photo by Karyn Gorra)

Mining Matters also works directly with high-school students. In 2008, a workshop was held for 36 students enrolled in a Specialist High Skills Major (SHSM) program. The High Skills Major, introduced by the provincial government in 2007, allows students to complete their studies while engaging in applied learning in a number of different specialist majors, including mining. Throughout the workshop, conducted during the annual Prospectors and Developers Association of Canada Convention, students engage in many activities, including a simulated field exploration program, a mining career panel discussion, a visit to the trade-show floor, and a presentation by a diamond-industry representative.

In addition to Aboriginal Out-

reach workshops delivered to northern communities, Mining Matters participated in the 2008 First Nations Natural Resources Youth Employment Program (FNNRYEP), held in partnership with Outland Forestry and Confederation College. The FNNRYEP is a seven-week, live-in professional and personal development program designed to facilitate future employment in the natural resource sector. Twenty-six youth, aged 15 to 19, travelled from 15 northern Ontario aboriginal communities to participate in the 2008 program. Mining Matters was pleased to provide six days of thematic educational programming that included earth science, environmental science, careers education and mining, as well as a visit to North American Palladium's Lac Des Iles mining operation.

SUPPORTING TEACHERS

During individual outreach events we meet up to 30 students over a limited time (typically one hour). Larger outreach events allow us to talk to more students and their parents, but for an even shorter time. Teachers, on the other hand, work with their students several times a week and can spark their interest more frequently. For example, half of the students attending the 'Girls Rock Science' seminars have heard about the program from a teacher. We think, therefore, that providing teachers with knowledge about earth science and with tools to teach it may be our most powerful option to attract students.

Our best course of action is to help teachers identify possible overlap between earth science concepts and the high-school curriculum they are expected to teach. The curriculum is determined by the provincial government with input from a number of outside groups, including teachers, universities and industry. Earth science topics in Ontario are taught at several grade levels, notably in Grade 4 (a unit on Rocks and Minerals, plus a unit within the Geography curriculum that discusses Canadian landforms and Geology), and in grades 11 (Physical Geography) and 12 (Space and Earth Science – SES4U). The Grade 12 course provides a framework for scientific literacy in the earth sciences, and covers a balanced range of topics (for rationale and curriculum expectations *see* Ontario Ministry of Education 2008). Unfortunately, SES4U is rarely offered because few school educators are qualified to teach it, and few universities list it as a mandatory prerequisite.

Earth science is by its very nature an interdisciplinary subject that draws from other sciences and also informs them. As a consequence, it should be able to enrich other subject areas. Because earth scientists must integrate concepts from many disciplines, the teaching of earth science concepts can serve as an umbrella to combine learning in various classes. For example, groundwater contamination can serve to examine concepts in chemistry (e.g. solutions and concentrations), physics (e.g. velocity and fluid flow), biology (bacterial growth), mathematics (statistics), and social studies (impact of mining on communities). Similar connections can be made for natural disasters, petroleum resources, the carbon cycle, and mineral properties. By learning about the same concept in different courses, students start to appreciate the connectedness and interdependence of our world.

Since 2007, the Geology Department has provided professional development in the form of one-day workshops for high-school teachers (Fig. 3). These workshops are sponsored by the Ontario Secondary Schools Teachers Federation (OSSTF) and are offered on a board-wide professional development day. Faculty from the department outline recent findings from their research and encourage teachers to explore ways to integrate earth-science examples into their classes. Mining Matters also participates by illustrating short versions of the activities they have developed. Demand for the sessions has been high; within an hour of going online, the registration limit was exceeded, and we were faced with an overflow of teachers on the day of the workshop. Because of this demand, we doubled our spaces for the second year, and offered two parallel sessions. The workshops were attended in the first year by 40 participants and in the second and third years by 90 participants.

Mining Matters also runs workshops for teachers. The success

Figure 3: Toronto Secondary School teachers taking part in a workshop in which they discovered how to identify rock-forming minerals.

of these workshops is evident in the continuing growth of the program; workshops are now being offered throughout Canada, whereby teachers can access modules directly linked to the school curriculum. The materials have been developed by industry representatives, educational specialists, and graphic artists who have collaboratively combined current information with hands-on, inquiry-based activities. Teachers appreciate having such easy access to relevant material.

A good electronic portal to access earth-science-related material can assist teachers when they are preparing their courses. It will be widely used by teachers if it is flexible, if it allows them easy access to material, and if it provides a discussion forum that teachers can readily access and to which they can contribute. For example, Toronto teachers of the Grade 12 earth science course and other interested teachers can access an earth-science-based forum through the Toronto District School Board's conferencing site (Toronto Education Link, or TEL), and use it for communication about course work, additional relevant websites, field-trip opportunities, and current geologic news. Establishing possible links between high-school subjects and earth-science topics is not a trivial exercise; an electronic portal, constructed for teachers by teachers, with input from industry and academia, can help in making these links.

LOBBYING

One of the objectives of our outreach strategy is to lobby ministry and university administrators. At these levels, the content of the high-school curricu-

lum and expectations for entrance into university are being discussed and decided; to improve the profile of earth science, we must establish increased influence at this level.

In our approach to the Ministry of Education, we suggest that an earth-science curriculum should be integrated into the Sciences, Mathematics, and Social Sciences, much as occurred recently with the broader inclusion of environmental education across curricula. The curriculum can be enriched by examples from the earth sciences, increasing the depth and breadth of related curricula in schools, thus helping to evolve a more scientifically literate society.

University entrance requirements are very confusing in relation to the Grade 12 Earth and Space Science course: although some universities accept it, others do not. As a consequence, the course is considered a 'soft' science option by students and by school counsellors. Because this outcome does not help to increase the reputation of earth science in high schools, we are lobbying universities to include the course as a prerequisite course for some university programs.

We need help in our lobbying efforts, because it is unlikely that ministry or university officials will respond to, let alone act on, the recommendations of one teacher, one faculty member, or one educational project manager. To be effective, we need support from the community and from individuals within the ministry and universities.

OUTLOOK

Society needs young people literate in the earth sciences. Well-trained students can expect to find exciting opportunities and fulfilling jobs in the earth sciences, where they will be able to tackle vital questions related to the future of our planet. Such is the key message we are trying to broadcast in our outreach efforts. Although it is too early to measure quantitatively the accomplishment of these efforts, anecdotal evidence presented above underscores the success of collaboration among representatives of industry, schools, and university communities. Positive feedback from students and teachers confirm that we are doing something important and achieving results.

At this time several issues remain. We need to find ways to measure our success, and thus identify the most effective ways to focus our outreach efforts. We need to find sources to fund this effort, because many of us do this important work in our spare time and on top of our regular work obligations. All of us – the mineral-resources industry, the petroleum industry, the environmental sector, academia, museums, earth-science societies, provincial and national geological surveys – need to work together to persuade policy makers of the significant contributions that the earth sciences have made, and will continue to provide, for the well being of society. To become more effective, we must share our ideas, our insights, and our approaches (successes as well as failures), at a national level and an international level. The Canadian Geoscience Education Network has been connecting interested parties from across Canada for many years in this regard. An opportunity for an international dialogue presented itself at the 2009 Joint Assembly in Toronto, where the authors of this paper convened a special session on effective outreach as well as a workshop on teaching earth science. Teachers, researchers, industry professionals and government representatives contributed ideas and engaged in lively discussions about what is needed. By sustaining this dialogue the earth-science community will help to ensure that today's students will be ready to make significant contributions in an area that is enormously important to the people living in our cities, in our countries, and on our planet.

ACKNOWLEDGEMENTS

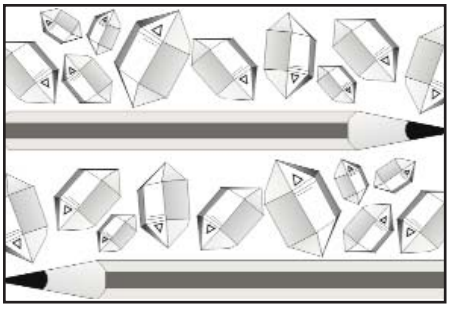
CGB thanks the Department of Geology, University of Toronto, and several enthusiastic undergraduate students for their contributions in support of his efforts.

REFERENCES

Nowlan, G.F., and D. Schreiner, 2007, The state of earth science outreach in Canada and an action plan for the future: Results of a session and workshop in Yellowknife, NWT, May 24-27, 2007: Geoscience Canada, v. 34, p. 49-54.

Ontario Ministry of Education, 2008, The Ontario Curriculum, Grades 11 and 12 – Science, [http://www.edu.gov.on.ca/eng/curriculum/secondary/2009science11_12.pdf]

SERIES



Geoheritage 4: Raising Public Awareness of Geological Heritage at L'Université du Québec à Chicoutimi

L. Paul Bédard, Hugues Longuépée, and Dany Savard
Sciences de la Terre
Université du Québec à Chicoutimi
Chicoutimi, QC, Canada, G7H 2B1
Corresponding author e-mail:
pbedard@uqac.ca

SUMMARY

Promotion of geological heritage is achieved through programs that increase the public awareness of geological phenomena and to draw attention to the importance of minerals in everyday life. Activities at the Université du Québec à Chicoutimi (UQAC) are divided into two parts: conservation and popularization. At the UQAC Petit musée mineral exhibit, the minerals on display are predominantly from the province of Québec, but samples from elsewhere in Canada and from the rest of the world are also presented to compare with Québec's geoheritage. More than a hundred samples from the Petit musée are described and photographically illustrated in a mineral identification guide (Bédard et al. 2008). Part of the collection can also be consulted on the web.

The Petit musée is not simply a mineral collection. Elementary and secondary school groups routinely visit the museum in conjunction with science popularization activities. For younger students, a story has been developed to present, in a light-hearted manner, some information about minerals and their uses. This story is centred on a hero who has many adventures in which minerals provide solutions to a series of problems. Older students participate in laboratory experiments that include observation of melting a rock, tasting and measuring salts in water and playing with the concept of density.

New exhibits presently being developed include a 'lead pencil' exhibit where the rich history of this common object is explored; another on mass extinctions presents the rich fossil heritage of Québec.

SOMMAIRE

Une bonne mise en valeur du patrimoine géologique nécessite une conscientisation de la population à la présence de phénomènes géologiques dans l'environnement immédiat et à l'utilité des minéraux dans la vie de tous les jours. Les interventions se divisent en deux grands volets, soit la conservation et la popularisation. Au Petit musée de l'UQAC, des échantillons minéralogiques provenant principalement du Québec sont conservés. Quelques échantillons d'autres régions du monde sont également exposés en guise de comparaison avec le patrimoine du Québec. Plus d'une centaine de minéraux du Petit musée sont présentés dans un livre grand public (Bédard et al. 2008). De plus, une partie de la collection peut être consultée en ligne.

Le Petit musée n'est cependant pas qu'une simple collection de minéraux. L'UQAC accueille régulièrement des groupes scolaires de niveau primaire et secondaire qui viennent visiter le Petit musée. Les visites d'élèves sont généralement accompagnées d'activités de vulgarisation scientifique. Ainsi, pour les plus jeunes, un conte a été développé pour présenter de façon amusante quelques minéraux et leurs utilisations. Le héro vit de nombreuses aventures dans lesquelles les minéraux offrent des solutions aux problèmes rencontrés. Pour les plus vieux, des activités de laboratoire sont offertes dans lesquelles ils peuvent observer une roche en fusion, mesurer et goûter la salinité de l'eau et expérimenter sur la densité.

Des nouveaux présentoirs sont en développement : une vitrine ayant comme thème le « crayon plomb » nous fera découvrir l'histoire riche de cet objet commun et des dioramas sur les grandes extinctions pour valoriser le patrimoine fossilifère québécois.

INTRODUCTION

Geological features and phenomena are often observed by the general public, but with little understanding beyond the fact that rocks are hard and solid and hurt if they strike you. Very few realize that modern amenities of life, such as television sets, houses, cars, computers and mp3 players would not be possible without minerals and their by-products. Although most of the public are less than happy to see mineral extraction in their backyard, they do not realize that modern consumer items require mining. Therefore, raising public awareness about the role of minerals in everyday life is, for

many reasons, very important. It enables one to better understand environmental issues such as global warming, and serves to elevate the level of general scientific culture. In addition, it can serve to increase student enrollment in geology programs in universities and colleges.

To address these issues, a program was developed at our university to reach out, at different levels, to the general public. Getting pre-teens, teenagers, and adults interested in minerals requires different approaches and techniques. Activities that succeed in getting the younger students interested do not work for the older teenage group, which is the most difficult group to engage. Through experience, we have found that the younger students will listen to a story that features minerals, whereas the older teenage students prefer to assist with popular laboratory experiments. Guided tours of our museum are offered to all ages, and presentations are made upon request.

TYPES OF APPROACH

Most of our various activities start with questions about the importance of minerals in modern life. Are minerals useful? How important are minerals in your life? We then discuss specific questions such as: Why are they important? What is made with minerals? Once they understand the logic, they start naming common products composed of minerals such as concrete, engines and pencils. Often we reverse the question: What is not made of minerals? Most soon realize that the list is limited to little more than wool, cotton, silk, and wood. This exercise allows them to better grasp the importance of the presentation.

Museum Guided Visits

This traditional approach involves guiding visitors through different displays (Fig. 1) that present minerals from different localities from the province of Québec, the rest of Canada and from around the world. This locality-based classification is used to present the mineral samples so that visitors can relate minerals to a location they know or are familiar with (e.g. where a relative lives). However, this method does not work as intended, as

Figure 1. Petit musée displays in university corridor.

we almost never get questions or comments on locality. Although this is not a serious problem, the desired effect is not being achieved, so our classification of minerals will have to be revised in the future. We are seeking to present minerals to visitors using their esthetic values, historical aspects and/or uses.

An effort is being made to link with school programs (geometry, physics, natural history, literature, history, etc). As an example, quartz from 'Cap Diamant' in Québec City is used to explain the (obviously now outdated) expression 'false as a Canadian diamond' by recounting historical anecdotes such as Jacques Cartier's discovery of Québec, at which time he mistook quartz for diamond. Graphite is used to explain how pencils are made and also to explain the origin of the 'lead pencil' name. A large stromatolite sample (Fig. 2) is used to introduce a discussion about blue-green algae, now a Canadian environmental problem. Stromatolites are also used to explain the first production of breathable oxygen and some notions about the origin of life. Moreover, we use stromatolites to discuss the science fiction literature genre, and speculate on the possibility of sending cyanobacteria to another planet to make it habitable.

Most mineral exhibits are presented in a traditional manner, i.e. with labels on individual mineral samples bearing information such as the mineral name, chemical composition, date of discovery, location, and donor's name. We believe we have reached a plateau using this type of presentation, because visitor interest saturates after 45 to 60 minutes of mineral description, history and uses. We also believe that simply showing more minerals will not get the general public more interested, no matter how spectacular the mineral samples. Therefore, a new type of presentation based on dioramas is now being designed. One display will be devoted to global extinctions, relating fossils and past climates. The other display will present common objects such as the pencil. Hematite in the eraser and clay and graphite in the pencil core will be shown, along with a description of how pencils are made. A section will focus on the history of pencils (use of lead, first graphite holder, etc.; Petroski 2003). A small section will address the differences between the mineral graphite and graphite in sports equipment (hockey sticks, golf clubs, etc.).

Figure 2. Stromatolite sample used to discuss blue-green algae.

Stories

The eight-year-old to early teenage group is introduced to minerals by telling them a story about minerals and their uses; the hero of the story, named 'Petro Graf', is trained by a character named 'G.O. Logue'. The story lasts about an hour and the adventure takes place approximately in the eighteenth century. In the first story, the hero comes from Europe to Canada to meet some *coureurs des bois* and "Indians". In the second story, he goes to Iceland and learns about volcanic rocks. Historical geological knowledge is taken from Agricola's De Re Metallica (1556). The heroes get themselves out of trouble by using their knowledge of minerals. As an example, when burglars ask for money, they give them pyrite which the burglars mistake for gold, and when fire is needed, they produce sparks by striking

pyrite and quartz together (this produces a nice and safe pyrotechnical effect in the dark classroom). Petro Graf stories are currently being written as novels.

"Ze big show"

The teenage group is the most difficult group to impress with stories or other presentations. To get them interested, we have developed popular activities such as melting a rock, water tasting and playing with densities. For the first activity, rock powder and flux are melted in a furnace and poured in the dark, behind a window for security purposes. The effect on the group is clear and their attention is very focused. The presentation allows us to explain volcanoes and lava, glass making, pyroanalysis techniques, etc. The other activity involves tasting bottled water from two different sources: Vichy Célestins water, which has a very high salt concentration (3350ppm), is tasted after a soft water such as Dasani (25-35ppm). Then, water conductivity is measured and discussed in relation to taste. During the final activity, the students weigh in their hand a small lead ingot (wrapped in plastic for health reasons) and compare it to a low-density material such as wood. Moreover, because the density of lead is comparable to gold, we discuss movies where robbers carry a large quantity of gold ingots as if they were made of wood or foam. These activities get their attention, so that they become more receptive to further information about the 'best profession in the world': geologist!

Talks and Presentations

Many schools and groups will ask for information on subjects such as volcanoes, meteorites, natural catastrophes and the geological professions. Members of our group, who have the best knowledge of the subject requested, will generally make the presentation, which, in most cases, takes the form of a computer-aided slide show.

Mineralogical Club and Shows

The Earth Science Department at UQAC sponsors the local mineralogical club (Club de minéralogie du Saguenay Lac Saint-Jean [http://mineraux.uqac.ca/club_mineralo_08/index_cm.html]) and hosts their activities. Often, geology department personnel will present talks on their field of expertise (paleontology, volcanology, geochemistry, mineralogy, etc.). This provides our geology department with volunteers for science popularization activities, and prompts members of the club to bring back samples from unknown localities. In return, we provide help with mineral identification and a room with appropriate samples for learning. Every two years, we present a gem and mineral show at the university. Approximately 3000 visitors come to the show during the weekend, which is good attendance for a city of 150 000. In contrast to similar shows, the UQAC gem and mineral show features special booths where geology, mining and local mineral-related industries are discussed. Typically, the show is planned around a specific theme accompanied by spectacular displays of, for example, gold, diamonds, or meteorites.

Publications

Presently, there are only two sources of information available from the Petit musée: our website and a mineral identification book. Some of the museum samples are presented on the Internet [http://mineraux.uqac.ca] along with a list of science-fair projects that can be undertaken by students. The book (Bédard et al. 2008) is a minerals field guide that uses samples displayed in the 'Petit musée'. Minerals are classified with an identification key. The book is divided into two sections based on mineral lustre. To identify a mineral, the reader must decide whether the mineral is metallic or non-metallic. We decided that it would not be productive to further divide non-metallic lustre into pearly, adamantine, etc. because this would not be practical or easily grasped by the neophyte. Then, within each section, minerals are classified with increasing hardness. From experience, we believe this is the easiest way to teach mineral identification to the neophyte. The book also has a section on meteorites because we get so many questions from members of the public who believe they have found a meteorite. Finally, there is a short section on geology as a profession.

CONCLUSIONS

Through the use of different approaches tailored to different clientele, we have managed to elicit a very strong response. As an example, we have more than doubled the number of inscriptions in our undergraduate program in the past five years. Raising public awareness is very important, if we expect the taxpayer to understand geological heritage and the usefulness of minerals and geologists to society.

ACKNOWLEDGEMENTS

Al Donaldson is thanked for his constructive comments on the manuscript and Julie Fredette is for reviewing the English on an early version of the manuscript.

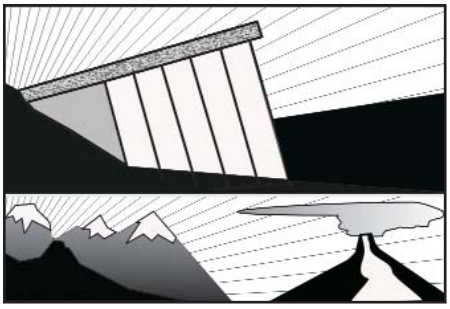
REFERENCES

Bédard, L.P., Larouche, J., and Hudon, P., 2008, Guide d'identification des minéraux: Broquet, Saint-Constant, QC, Canada, 207 p.

Agricola, G., 1556, De Re Metallica, translated by L.H. Hoover and H.C. Hoover 1950: Dover Publications Inc., New York, 638 p.

Petroski, H., 2003, The Pencil: Alfred A. Knopf, New York, 434 p.

ARTICLE



The Johnson GEO CENTRE: Earth's Geological Showcase

R. Frank Blackwood
Member of the Board
Johnson GEO CENTRE
175 Signal Hill Road
St. John's, NL, Canada A1A 1B2
E-mail: frankblackwood@nf.sympatico.ca

SUMMARY
The Johnson GEO CENTRE is a geological museum in St. John's. It was built by Mr. Paul Johnson, a retired St. John's businessman and philanthropist, after he became captivated by geology. The uniquely constructed CENTRE has several exhibits that explain the fundamentals of geoscience, demonstrate Earth history through the geology of Newfoundland and Labrador, show the evolution and world-wide migration of human beings, and emphasize the importance of Earth resources and good stewardship to the future of Earth's peoples. Students are welcomed by entertaining, curriculum-based, geo-education programs. These and other public-awareness-of-geoscience activities are the main focus for GEO's dedicated staff and volunteers.

SOMMAIRE
Le *Johnson Geo Centre* est un musée géologique situé à St. John's. Il a été construit par M. Paul Johnson, un homme d'affaire à la retraite et philanthrope, après qu'il se fut passionné pour la géologie. La construction unique du *Centre* comporte plusieurs expositions qui expliquent les principes de base des géosciences; décrivent l'histoire de la Terre en s'appuyant sur la géologie de Terre-Neuve et Labrador; montrent l'évolution humaine et ses grandes migrations; et soulignent l'importance des ressources terrestres et la nécessité d'une bonne intendance à cet égard, pour l'avenir des peuples de la Terre. Les programmes de géo-éducation du *Centre* offrent aux étudiants des contenus amusants et adaptés à leur niveau académique. Ces programmes et autres activités de sensibilisation du public aux géosciences constituent le principal centre d'intérêt des employés et bénévoles dévoués du *Geo*.

INTRODUCTION
The Johnson GEO CENTRE is a first-class geological museum on Signal Hill in St. John's, Newfoundland. The story of its origins, and what it strives to achieve, naturally begins with its founder, Mr. Paul Johnson (Fig. 1). Understanding his inspiration may provide clues as to how we might further Ward Neale's work of spreading the Gospel of Geoscience to the citizens of Canada.

Mr. Johnson is a St. John's businessman (now retired) under whose leadership the family insurance business, founded in Newfoundland in 1880, was grown to a Canada-wide provider of insurance and benefit services. Always a strong supporter of his community, and an exceptionally proud Newfoundlander, he established the Johnson Family Foundation (JFF) in 1987 to help preserve the province's unique heritage and pursue other educational projects. One of his early projects was working with Parks Canada to recreate some of the late-1700s military infrastructure on Signal Hill.

Figure 1. Paul Jolliffe Johnson, C.M., O.N.L., LL.D. (Photo courtesy of the Johnson Family Foundation)

Signal Hill is an iconic landmark on the north side of the entrance to historic St. John's Harbour. Controlling its commanding heights was a preoccupation for (and contest between) the British and French militaries throughout most of Newfoundland's colonial history. Its crown also contains the imposing Cabot Tower, built in 1897 to commemorate the 400th anniversary of Cabot's discovery of Newfoundland and Queen Victoria's Diamond Jubilee. After an agreement with Parks Canada, the JFF researched and built a late-18th-century stockade

wall near the Tower, an enhancement to the federal park that is much appreciated by the annual 700 000 visitors to Signal Hill.

Once his attention had turned to Signal Hill, Mr. Johnson became interested in constructing walkways from the famous Hill to the equally famous Quidi Vidi Lake, home of the Royal St. John's Regatta, the oldest continuously held sporting event in all of North America. (This initial walkway construction led to the formation by JFF of the Grand Concourse Authority, now responsible for a system of trails in the cities of St. John's and Mount Pearl that rival any in urban Canada.) Then it happened! During the planning for the trails leading down from Signal Hill, Mr. Johnson was introduced to, and seduced by, the wonders of geology.

Dr. Arthur King of Memorial University (and GAC Neale Medallist for 1997) was consulted on the rock formations exposed along the trails to Quidi Vidi Lake. Professor King is the leading researcher on the late Precambrian rocks of Signal Hill, and indeed the whole Avalon Peninsula, and he was soon regaling Mr. Johnson on the antiquity (more than 500 million years old!) of these rocks, their sedimentary features (ancient beaches, rippled sands!) and their uniqueness (more akin to Africa than North America!).

Our philanthropist was hooked, and was soon conferring with Dr. Hank Williams, also of Memorial University (and GAC Logan Medallist for 1988) and of Appalachian-geology fame, on the spectacular geology of Newfoundland and its importance in understanding plate-tectonic theory around the planet. Mr. Johnson thus became fascinated with the revelations that a large ocean, 450 million years ago, once separated western Newfoundland from what is now the eastern reaches of the Island; that this proto-Atlantic ocean was destroyed, resulting in the formation of the Appalachian Mountains; that the erosion of said mountains produced the sediments for our current Grand Bank shoals; and that Labrador has some of the oldest rocks in the world dating back almost 4 billion (!) years. Added to this, he was given to understand that these geoscientific concepts are integral to the sustainable exploitation of the province's rich mineral and hydrocarbon resources. With this awareness, the nexus between captivating geology and philanthropic resources was complete.

Thus inspired, Mr. Johnson sought to share his geological epiphany with his fellow citizens. In 1997, he formed a five-person Planning Team to assess the viability of building a state-of-the-art geological museum/interpretation centre on (where else?) Signal Hill. This was a blue-ribbon group of individuals whose identity will help convey the foresight and commitment that went into the planning of the GEO CENTRE. The team consisted of, in alphabetical order: former Director of the Geological Survey of Newfoundland and subsequent founding Director of the Royal Tyrrell Museum of Paleontology, Dr. David Baird; acclaimed St. John's-based architect, Mr. Charles Cullum; Memorial University geophysicist and leader in the Canadian Earth-science community, Professor Jeremy Hall; former librarian and Secretary to the Johnson Family Foundation, Ms. Heddy Peddle; and exhibit designer and consultant, Mr. George Quigley.

To ascertain what constitutes a superior geological museum, and what elements have the greatest success in attracting and informing visitors, the Planning Team visited eight such museums in Canada, the United States and Great Britain. By late 1997 their assessment report was done and presented to Mr. Johnson; it contained the enthusiastic recommendation that a GEO CENTRE could and should be constructed on Signal Hill, but that it would cost several more millions of dollars than originally anticipated. Undeterred, the Johnson Family Foundation immediately secured rights to the land, committed millions of Foundation dollars, and leveraged millions more, to underwrite the approximately $12-million facility that would be built on this historic site.

Once the "go" decision was made, Mr. Cullum began work in earnest on the CENTRE's unique architectural design, which was completed in 2000. It was decided to minimize the footprint and skyline impact of the structure on historic Signal Hill by utilizing a sculpted glacial depression to construct the main body of the exhibit centre. Glacial debris was removed, and the revealed, striated, valley walls became the bounding walls (left exposed in the building) of the GEO CENTRE. Access to the exhibits would be through a glass-encased portal (Fig. 2) whose roof sloped downward toward the exhibit hall, which lay below the surface in the natural depression, inviting visitors to explore the Earthly delights below: *The Wonder Underground* was born!

Figure 2. Portal to the Johnson GEO CENTRE. (Photo taken by and courtesy of Becki Peckham)

During the next two years, while construction proceeded, work progressed on the heart and soul of the GEO CENTRE: its Storyline and Exhibits. A Storyline Committee of geologists, chaired by Professor Hall, developed the story, multimedia presentations and, of course, rock specimens, of Earth's (and the province's) geological history. Exhibit design, videos and hardware construction were undertaken by the Atlantic Canada firm of Strata Group, which was specifically incorporated for the GEO project. All was ready for the Grand Opening of the Johnson GEO CENTRE in the spring of 2002, a gala event attended by local dignitaries and Canadian movie and TV celebrity Mr. Gordon Pinsent (who had also narrated the multimedia presentation for the CENTRE's *Geo Theatre*). A dedicated and knowledgeable staff was in place under founding Executive Director Mr. Robert Grantham, all reporting to a Board of Directors chaired by Mr. Johnson. His dream had been realized, and the world-class showcase to the magnificence and wonderment of Earth's geological story was ready to enthrall and educate visitors by the

thousands. Below, more detail is presented on the GEO CENTRE's exhibits (original and recent), its educational and outreach programs, and its future plans.

EARTH'S GEOLOGICAL SHOWCASE

The Johnson GEO CENTRE styles itself as *Earth's Geological Showcase*. Through exhibits (permanent and travelling), audiovisual presentations, educational programs, outreach activities and key alliances, it hopes to instill in the public an understanding and appreciation of the antiquity, evolution and dynamism of planet Earth, and the relationship between people and Earth, including the societal importance of the sustainable use of Earth resources. The depiction of Newfoundland and Labrador's own geological story is used to generate awe and understanding of its many phenomena, and to complement the telling of the geological evolution of the Earth itself. The following is a brief description of the main exhibits of GEO, to show how they present (geared to a Grade 9 student) a holistic picture of Earth and life on it, and how the public may be informed of, and (we hope) amazed by, the story of our planet.

Geo Theatre

GEO's unique portal – the sloping roof and glass walls complement the angularity of the steeply dipping beds and joints on Signal Hill (Fig. 2) – houses a kiosk, coffee counter and a well-stocked Gift Shop. Proceeding to the back of the portal, visitors take glass-door elevators down to the Reception Hall. This is a large, three-story-high, open area wherein coloured spheres representing the solar system (planets plus their satellites and rings) are suspended from the ceiling (and in full view while descending in the elevators). At the back of the Reception Hall, and in front of the Exhibits Gallery, is the granite-clad entrance to the *Geo Theatre*, where a continuously playing multimedia presentation provides the introduction to GEO (Fig. 3).

The presentation tells the story of the birth of the solar system through to the formation and evolution of Earth. During its showing, special effects in the theatre, including sound, light and music, dramatize

Figure 3. Reception Hall and Geo Theatre. The main Exhibits Gallery is behind the Theatre. (This and following photographs are courtesy of the Johnson GEO CENTRE)

events with spinning orbs, simulated red-hot rocks, thunder, simulated smoke, real running water and 'rain'. The show is interrupted periodically as narrator and 'geologist' Gordon Pinsent 'appears' from a crevice in the 'rock face' that surrounds the screen to highlight particular points for clarity and interest. Graphics and Newfoundland and Labrador rocks and scenery are used in the film to demonstrate the various geological phenomena being portrayed, such as plate tectonics, the ice ages, the harbouring of life on the Blue Planet, the importance of the biosphere, and the fundamental need for sustainable use of Earth's resources. Just as the 16-minute presentation is ending to stirring Newfoundland music, viewers are invited to begin their tour of the GEO CENTRE, as side doors to the theatre automatically open at the start of the Exhibits Gallery.

Our Planet

The first exhibit in the touring sequence of the Exhibits Gallery (directed by arrows on the floor) is called *Our Planet*; it provides a primer on how Earth works. Through models, demos, audiovisuals, posters and samples, the main concepts of earth science are explicated.

The pre-eminence of the sun and its influence on our planet are acknowledged; the rock and water cycles highlighted; weathering and weathering products shown; and mountain uplift depicted to continue the theme of Earth's dynamism (Fig. 4). Explaining the Earth's internal heat

Figure 4. Dynamic Earth explained in *Our Planet* exhibit.

from radioactive decay leads to the subject of melting and igneous rocks, including, of course, volcanoes (demonstrated in specimens and video). Weathering phenomena help introduce sedimentation and layering of sedimentary rocks (grain-size settling is featured in a neat hands-on demo). Earth forces are used to introduce plate tectonics and explain earthquakes, metamorphic rocks and folding. The overall structure of the Earth (including an animated core-to-crust 3-D model) and the composition of the crust provide context for a rock-and-mineral display of high-quality specimens.

Perhaps that most difficult (and important) of geological concepts to convey to a lay audience – deep geologic time – is dealt with in *Our Planet*. A large annotated time scale, several metres long, is presented of course, but some understanding of what the billions of years mean is demonstrated in the adjacent 'Sands of Time' display. At this display, transparent columns contain grains of sand, from just 75 grains to represent a 75-year human life span in a virtually empty column, to millions of grains in a filled metre-high column to show the time of dinosaur extinction 65 million years ago. A floor-to-ceiling column filled with sand, and showing its continuing (by graphic) through the roof of the GEO CENTRE and reaching well above it, attempts to give an organic feel for the immense antiquity of the Earth. Located nearby, a display on the importance of superposition of strata in sediments, as well as the fossils these layers contain, relates chronology and evolution of life. Geochronology and unconformities are also introduced.

Visitors leave *Our Planet*, we hope, with a basic understanding of the age and dynamism of Earth, and how these fundamentals influence several key geological processes, thereby ready to enjoy and understand the rest that GEO has to offer.

Our Province

It's no secret that Newfoundland is geologically renowned for its preservation and exposure of rocks that record the formation and closure of the proto-Atlantic or *Iapetus Ocean*. Spectacular coastal exposures and glacially scoured hilltops provide an unparalleled cross-section through continental margins, oceanic crust (*in situ* and obducted), island arcs, back arcs, and sedimentary basins. Similarly, the magnificent exposures along the shorelines and barrens of Labrador are a boon to unravelling the mysteries of the Canadian Shield in eastern Canada. With some of Canada's oldest rocks (at nearly 4 billion years) in northern Labrador, and hydrocarbon-rich Mesozoic rocks underlying the continental shelf, the province's geology represents a significant swath of Earth history (Fig. 5).

Figure 5. Entrance to *Our Province* exhibit. The block of rock at the start is a piece of obducted mantle from western Newfoundland.

Newfoundland (Appalachian) and Labrador (Canadian Shield) geology are treated separately in the exhibit. Two circular modules with multiple TV monitors suspended over representative rock samples tell the story of these two distinct regions in audiovisual format. The *Labrador – An Ancient Land* video deals with the great age of the Canadian Shield and how it was constructed through continental accretion, the result of which we see today in the various structural provinces. The development of an oxygen-rich atmosphere is highlighted by the deposition of the great iron deposits of western Labrador. Igneous activity includes reference to the famous Labrador anorthosites and the Voisey's Bay nickel deposit. The Labrador story ends with the beginning of the Newfoundland story 600 million years ago.

The *Newfoundland – A Younger Land* video starts with the breakup of Rodinia. It takes us through to the development of the Appalachian Mountains and the formation of Pangea, with stops in between, such as the obduction of ophiolites exposed at the UNESCO World Heritage Site in Gros Morne National Park, western Newfoundland. Plate tectonics, continental drift and the famous continent – ocean – continent zonation of Newfoundland are all covered. The role of the redoubtable Dr. Hank Williams in deciphering this history, as well as his acclaimed Map of the Appalachians, is a separate feature in the exhibit. The Newfoundland Island story ends with the beginning of the modern Atlantic Ocean.

A third module shows the *Birth of the Atlantic* video. It starts with the breakup of Pangea and the formation of the continental shelves as the modern Atlantic gets ever wider. Rift valleys, erosion, flood plains, sedimentary basins, and marine organisms are all explained as contributors to the world-famous Grand Banks of Newfoundland and the eventual formation of offshore oil and gas deposits. Imaginations are stirred by the explanation that dinosaurs once roamed the long-buried marshlands of the continental shelf, that a still-spreading Atlantic Ocean causes periodic seismic activity in eastern Canada, and that on our restless planet, erosion and deposition are continuous processes.

The eastern zone of Newfoundland, underlain by 'Avalonia', gets its own treatment in *Our Province*. Suffice it to say that this exotic piece of geology, a remnant of Gondwanaland left behind after the breakup of Pangea, is the 'home' of the GEO CENTRE and is given special attention. Its mineral deposits and fossils (including the incredible Ediacaran fauna at Mistaken Point) are all highlighted. Near this part of the exhibit, a series of globes shows the travels of the continents since the Neoproterozoic, from Rodinia to Pangea to today's configuration.

Our Province ends with a treatment of glaciation in a special 'glacier' theatre (temperature is kept a few degrees cooler inside) where a video narrated again by Mr. Pinsent explains the impact of the ice ages on the world, Canada, and Newfoundland and Labrador. The video ends with life (including people) re-inhabiting the land after the last ice age. Upon leaving this mini-theatre, one hopes the visitor has seen Earth history through the geology of Newfoundland and Labrador, and is ready for the next exhibit.

Our People

Visitors to the *Our People* exhibit are welcomed by a large Inukshuk made from stones shipped from Labrador, to represent the Thule and Inuit cultures of Labrador and northern Canada. An Inuit Labradorian assembled the Inukshuk before the opening of GEO.

In this exhibit, human origins and development (the main focus) are considered in the context of the evolution of life on Earth. It explains that single-celled life began billions of years ago and evolved through the complex life forms represented in the fossil record, to those present today. Throughout the vastness of time, many species became extinct and new ones evolved, largely owing to changing conditions on Earth. The exhibit explains that very late in the story of life, *Homo sapiens* evolved from primate ancestors. Early hominids are dramatized by replicas of the Laetoli Trackway - fossilized footprints from Tanzania, and 'Lucy' - a partial *Australopithecus afarensis* skeleton from Ethiopia (Fig. 6).

The evolution from primitive to modern humans and the migration out of Africa are documented in words and graphics. The peopling of North America (eastward migration from Asia) is shown to occur in the wake of the retreating Laurentide ice sheet, including the movement of aboriginal peoples into Newfoundland and Labrador. With the westward journeys

Figure 6. An Inukshuk greets visitors to the *Our People* exhibit. 'Lucy' is in the background.

of Europeans to the 'New World', beginning when Viking voyagers meet native North Americans in Newfoundland around 1000 C.E., human beings have completed a 'full circle' from their African birthplace.

The second part of the *Our People* exhibit deals with our contemporary world and civilization's dependence on Earth's resources, geological and otherwise. A modern-kitchen display with an audio commentary entitled *Out of the Earth* demonstrates the omnipresence of mineral products in our everyday lives. A prospector-camp display/mini-theatre shows a video entitled *Searching for Knowledge; Searching for Wealth* wherein the importance of geological maps (and the historical evolution of same in Newfoundland and Labrador) is declared crucial for modern-day mineral and hydrocarbon exploration. Visitors are reminded that the land and sea have always provided for man's sustenance, and that a quest for knowledge is fundamental to our future sustainable use of Earth's bounty.

Our Future

The penultimate exhibit in the main Exhibits Gallery is *Our Future*. It consists of a video called *Earth's Future, Our Future*, and it plays in a dome-shaped mini-theatre. The video focuses on the changing nature of our planet, from its fiery birth to today's life-conducive conditions. The pivotal role of the sun and terrestrial events like volcanism are related to Earth's changing climate throughout geologic time. Cooling and warming cycles, and the related glacial advances and retreats, are explained, as well as the impact of greenhouse gases on global warming. Contemporary concerns about climate change are presented in the context of Earth history, scientific research, the use of fossil fuels, and the potential for both positive and negative impacts. The video also deals with our use of resources, including fossil fuels and alternate energy. And the importance of clean, safe water is emphasized. Finally, we are reminded of the need for good stewardship with the closing exhortation: *"So whether your home is here in Newfoundland and Labrador, or any other nation on the globe, treasure and protect this world, and our Earth will always be the Blue Planet."*

The Stellarium

The final exhibit in the main Exhibits Gallery is a stellarium, located at the back of the gallery. It brings together the Space theme introduced by the impressive solar-system display in the Reception Hall. (In fact, Space is a significant ancillary theme at the GEO CENTRE, which has concluded an agreement with NASA to broadcast its video feed from the Mars Rover program in GEO's 85-seat auditorium located off the Reception Hall.) As well as a tour through the 250 stars closest to our solar system, the *Stellarium* voice-over provides a description of our sun's giant-to-dwarf future. In the 'foyer' of the stellarium exhibit, numerous photos of space and the Manned Space Platform are mounted.

GEO's Rock Walls

Returning to the Reception Hall from the *Stellarium*, one walks along the exposed, steeply dipping, bedded-sandstone walls of the GEO CENTRE (Fig. 7). Signage touts the antiquity of these rocks in relation to other seminal events in the geological evolution of the Earth and of Canada, e.g. the age of dinosaurs, and the birth of the Rocky Mountains. The walls are a magnet for children (although rock climbing is prohibited for safety reasons!), and various primary features developed on the bedding surfaces, as well as cracks and veins, get pointed out to visitors by GEO's interpretation staff. Arriving back in the Reception Hall, one has truly gained the impression that the GEO CENTRE is *The Wonder Underground*.

Figure 7. Exposed! GEO's sandstone walls bound the main Exhibits Gallery.

ExxonMobil Oil and Gas Gallery

Built after the opening of GEO, the *ExxonMobil Oil and Gas Gallery* is a state-of-the-art exhibit on hydrocarbons, from their geological formation to end uses, and, naturally, this being Newfoundland and Labrador, an emphasis is placed on their occurrence and extraction in the offshore. A partnership was entered into with ExxonMobil Canada to sponsor GEO's oil-and-gas gallery. A Storyline Committee, chaired by GEO and including geoscientists from the company, was established to determine, and write, the content for the exhibit. The gallery was opened to the public in June 2005, and is a sterling example of what can be achieved by active corporate participation in GEO's educational mission.

The unique entrance to the *ExxonMobil Oil and Gas Gallery* is off the Reception Hall, and simulates in design, material and sound, a transport helicopter landing on the helipad of an offshore oil platform. Once 'landed', visitors are treated to a display of familiar materials that highlight the importance of petroleum products in our everyday lives. Next, through posters, audiovisuals, and interactive props, the science of hydrocarbons is explained: What are oil and gas? Where do they come from? The chemistry of hydrocarbons, how they formed from organic remains in sedimentary rocks, the importance of porosity and permeability, and the development of sedimentary basins and reservoirs, are all explained and depicted.

Exploring for hydrocarbons is covered, particularly the use of seismic surveys, geological interpretation and drilling. A mini-theatre offers a custom-made video (as are all of GEO's

videos) that deals with offshore exploration and recovery, focusing on the science and technology involved, such as horizontal drilling. Just beyond the theatre, the exhibit focuses on the extraction of oil, with large, detailed models of the *SeaRose*, a Floating Production, Storage and Offloading (FPSO) vessel used in the White Rose field, and the Hibernia Platform. Getting oil to market is also covered (by tankers, trucks etc.), including the refining that renders crude into the useful, familiar products that we use daily. The industry's focus on protection of the environment and workers' safety is emphasized, along with the need for constant vigilance, poignantly so with the exhibit's acknowledgement of the tragic loss of the *Ocean Ranger* drilling platform in 1982, during the early years of offshore exploration.

The *ExxonMobil Oil and Gas Gallery*, near its end, looks at our energy needs and uses in the future, including alternative forms of energy (pointing out that the Johnson GEO CENTRE itself is heated and cooled by a geothermal heating system). In conclusion, the point is made that for this exciting, high-tech industry to thrive, it is essential to have centres of excellence, such as Memorial University, to produce the workers needed for the diverse careers in exploration, discovery, extraction, and delivery of oil and gas.

The Titanic Story

A somewhat unusual exhibit, given that the GEO CENTRE's focus is on earth science, tells the story of the *Titanic* and her tragic sinking in 1912 after colliding with an iceberg 560 km to the southeast of Newfoundland. Mr. Johnson was made aware of a collection of *Titanic* reproductions, artifacts (removed from the actual ship before her sailing) and movie props (from Mr. James Cameron's famous movie) that needed a place for permanent display. A room off the Reception Hall was made available, and the production of posters, displays and models (including the famous ship as she presently lies on the bottom of the North Atlantic, and as she was discovered by renowned earth scientist, oceanographer and explorer Dr. Robert Ballard) was done to exacting GEO exhibit standards.

The Titanic Story opened in 2004, and has become a very popular exhibit with visitors. It provides an absorbing digression from GEO's theme, although the age-old annual calving of icebergs off Greenland's glacier (a remnant of the Laurentide ice sheet), the ocean currents that produce 'iceberg alley' off Newfoundland's shores, and the discovery of the wreck of the *Titanic*, are all elements that fall within the embrace of GEO's natural-history mandate. In any event, regular visitors, as well as amateur *Titanic* historians, have all lauded the exhibit as one of the best they have seen.

Kids Room

As previously mentioned, the exhibits at the GEO CENTRE are written to a Grade 9 junior-high-school standard. Obviously, however, many younger visitors often accompany older family members on a trip to GEO. Besides educational programs specifically oriented to primary-school kids, GEO uses mobile *Kids exhibits*, placed strategically through the facility, to engross and entertain the younger set (e.g. a xylophone made of drill core). Recently this concept was expanded into a *Kids Room*, again off the Reception Hall, wherein the walls are painted with age-appropriate images of space, primordial Earth, fossils and dinosaurs, and mounted 3-D depictions of crystals. Play stations are placed throughout the room, including a puppet theatre. This room has become very popular with families: while one adult supervises the younger children in the *Kids Room*, the other adult(s) can accompany the older kids around the main exhibits.

JOHNSON GEO PARK

Surrounding the GEO CENTRE on three sides is the 15-hectare Johnson GEO PARK (Fig. 8). When Mr. Johnson secured the long-term lease from the provincial government for the GEO CENTRE, it contained provisions for expansion of the lease to include a geological park. To plan the park, Mr. Johnson secured the foundational involvement of two prominent scientists from Memorial University: Dr. Arthur King, geoscientist and

Figure 8. GEO PARK overlooks the city of St. John's. In the foreground are some of the PARK's trails, outcrops and stoneworks.

aforementioned inspirer for the Johnson GEO CENTRE; and Dr. Wilf Nicholls, botanist and Director of Memorial's Botanical Garden. The interpretative focus of GEO PARK is the geology and botany represented in the natural landscape surrounding the GEO CENTRE on Signal Hill. Subsequent to its completion, ownership of GEO PARK was formally transferred to the Johnson GEO CENTRE Foundation Inc.

GEO PARK contains eight, wheelchair-accessible, looped walkways of nearly two kilometres in aggregate length that are disposed around the GEO CENTRE. From just about anywhere in the PARK, the spectacular panorama of the city of St. John's, including its locational relationship to the area's geology and geomorphology, is visible. Along the walkways, Johnson Family Foundation-patented Historyboards® explicate in text and graphics the regional and landscape features of the geology, as well as outcrop-scale features and phenomena. Similarly, the PARK's botany is the focus of Historyboards® that explain the role of climate and soil in plant development, and highlight the various native and introduced species in the PARK.

A bonus feature of GEO PARK is the development of eleven models of traditional stone structures used in Newfoundland and Labrador. Designed by GEO CENTRE architect Charles Cullum, the stonework replicas are disposed along the PARK's first walkway and represent such past and present structures as fireplaces, root cellars, wharfs and Inukshuks. The Stoneworks Walk is a fascinating cul-

tural complement to the natural-history focus of GEO PARK.

GEO PARK also includes a 'traverse' across Newfoundland's main tectonostratigraphic zones as represented by 1- to 2-tonne blocks of cut-and-polished representative rock types situated close to the CENTRE's entrance. All together, the PARK represents a tremendous asset to the GEO CENTRE and its mission. It is free to visitors and is an inducement for them to visit the CENTRE for an expansion on the GEO experience. Guided tours of the PARK are provided by GEO's interpretation staff, and its educational and scenic appeal is included and promoted in GEO's programming.

GEO EDUCATION AND OUTREACH

The exhibits at the GEO CENTRE, and the uniqueness of the facility itself, are the primary features that attract and educate the general public, young and old. However, the CENTRE has a formal educational program directed at students that is both substantive and effective. Called *Geo Classes*, these are currently developed and aimed at grades 2-6. Material in the classes (held in two classrooms off the Reception Hall in which one side in each room is the exposed rock wall) has been developed by GEO staff in active consultation with science teachers, for school-curriculum conformity and age-appropriate detail. Lasting one-and-one-half hours each, students in these classes assume the role of scientists who are researching various topics, for example, the water cycle for Grade 2, and rocks and minerals for Grade 4. Classes are led by GEO Interpreters and can accommodate up to 60 students at a time (must be booked in advance by schools). The CENTRE hosts, on average, 70 *Geo Classes* a year to teachers' acclaim and students' delight.

Complementing *Geo Classes* is the *School Visits* program. Open to all grade levels from K to 12, and available throughout the week, these are one-and-one-half-hour sessions that consist of a 20-minute presentation by Interpretation staff, the multimedia show in the *Geo Theatre*, and a tour through the exhibit galleries. Again, through content, worksheets and focus, these visits are geared to the various grade levels and particular course curricula, and include such offerings as *The Whispering Rock* (rock types, etc.), *Waves of Tragedy* (tidal waves with Newfoundland example), and *Buried in Ice* (glaciation). Finally, student groups are offered tours of the geological, botanical and cultural points of interest in the GEO PARK.

Most current formal student programming is directed at the elementary grades; junior-high classes are in development. However, a major teaching resource, the *Geo EDUKIT*, as of spring 2009, is being piloted by five science teachers to ensure its maximum compatibility as a support to Newfoundland and Labrador's high-school earth-science course. Once final modifications are made, the *EDUKIT* will be distributed to schools. It consists of a substantive package of lesson plans, worksheets, demonstrations, maps, rock and mineral specimens and other helpful materials. Funding for developing the kit was provided by the JFF, NSERC's *PromoScience Program,* and ExxonMobil.

Situated as it is in the easternmost part of Newfoundland and Labrador, the Johnson GEO CENTRE has a keen desire to make its educational resources available to students throughout the province via a *Distance Education Program*. To this end, it is entering into discussions with the provincial Department of Education and, particularly, its Centre for Distance Education and Innovation, to investigate ways of providing resources and inspiration for all students eager to learn about the Earth. To achieve these goals, the GEO CENTRE will use computer technology, travelling displays, school visits and the distribution of hands-on materials. This is a major undertaking, and its success will depend upon developing effective partnerships with like-minded agencies and public-spirited benefactors.

Proactive educational outreach is an ongoing priority for GEO staff and Board committees. For example, space and facilities are given free for teacher in-services, in exchange for their receiving an information session on GEO's programs and exhibits. Teachers are invited to comment on and modify all GEO programs developed for the schools. And a good working relationship is maintained with curriculum developers in the Department of Education.

Public Lectures are a free and regular feature at the GEO CENTRE, and those presented to commemorate the International Year of Planet Earth (IYPE) have been especially well attended (speakers have come from the St. John's geoscience community, the Geological Survey of Canada, and even internationally, e.g. Dr. Robert Ballard, scientist emeritus, Woods Hole Oceanographic Institute). The general public and students are also invited to a series of *Special Events* hosted by GEO throughout the year. These include Earth Day celebrations (featuring, for example, 'Stump a Geologist', 'Panning for Gold' (Fig. 9), and solar observations guided by members of the St. John's chapter of the Royal Astronomical Society of Canada); a bridge-building competition sponsored by National Engineering and Geoscience Week; and 'Doors Open St. John's', an event during which the GEO CENTRE and other museums and institutions in the city offer a free exploration of exhibits and facilities. Finally, GEO renews interest in its mission and complements its permanent galleries by hosting *Travelling Exhibits*, mostly during the off season. These are displayed in the Celestial Gallery, new space developed at the entry level and leading off the main entrance. Some of these temporary exhibits have enjoyed corporate sponsorship and helped generate valuable media interest. Exhibits hosted to date include: Dinosaurs and Company, From Crystals to Gems, and Arctic Adventure.

Figure 9. Panning for gold at a 'mineral exploration camp'.

PARTNERSHIPS

For any successful public-education endeavour, developing effective partnerships is key to leveraging greater goal-oriented effort and ensuring success. By pursuing this strategy, the Johnson GEO CENTRE enjoys a number of mutually beneficial relationships with local and national institutions and organizations. The most consequential is its partnership with Memorial University of Newfoundland (MUN), as formalized through the negotiated 2007 Management Agreement Plan (MAP). The MAP recognizes that the GEO CENTRE benefits from the active involvement of the university in its programming and governance (six of 11 Board members come from Memorial), and that MUN students, faculty and staff have much to gain from GEO's exhibits, facilities and programs.

The GEO CENTRE also enjoys an informal partnership with the Earth Sciences Department at MUN. Faculty members give public lectures at GEO, serve on the Board and bring first-year students to the exhibits. Likewise, geoscientists from the Geological Survey of Newfoundland and Labrador (GSNL) of the provincial Department of Natural Resources, are devoted supporters of the GEO mission through public lectures, sample collections, exhibits development and special-events participation. Clearly, MUN earth sciences and GSNL are two fundamentally important partners in achieving GEO's goals.

Other groups with which GEO is affiliated/associated include the Canadian Space Agency (Canadian astronaut Julie Payette visited GEO and made a presentation to 400 school kids); the Museum Association of Newfoundland and Labrador (which provides an opportunity to share experiences and problem solving with confreres operating in the same environment); the Canadian Association of Science Centres (which extends membership privileges to all members of participating centres across Canada); the Newfoundland and Labrador Section of the Geological Association of Canada (which meets regularly at the GEO CENTRE and sponsors an annual public lecture there); the local chapter of the Royal Astronomical Society of Canada (which meets at GEO and sponsors educational events at the CENTRE); and the Royal Ontario Museum (which was involved in a project to produce a cast of the bedding surface at Mistaken Point, Newfoundland, that contains the world-famous Ediacaran fossils). Finally, GEO participates in a *MultiPass* program with other museums and exhibitions in St. John's and environs, to facilitate visitation to the several local venues by those with a penchant for learning and fun.

FUTURE PLANS

The Johnson GEO CENTRE opened its doors in 2002. Since then, two major exhibits have been added to the original gallery. There is one important area, however, that was always part of the original plan but has yet to be constructed, and that is a *Mines and Minerals Gallery*. A preliminary proposal for the gallery has been prepared by the Board's Curatorial Committee, and approaches have been made to several large mining companies with the hope of securing a patron for *Mines and Minerals* similar to the way ExxonMobil sponsored the *Oil and Gas Gallery*. The new gallery will cover the geological origins, historical uses and societal impacts of minerals. Current plans also include an adit off the gallery to give visitors a sense, as close as possible, of what it is like to be in an underground mine. Active fundraising for this project is ongoing.

Of course, renewing exhibits and planning new ones are essential to keeping GEO vital, relevant and attractive to the visiting public. Other smaller exhibits in the works include a *Paleontology Display* focusing on the fossils of Newfoundland, and a *Geothermal Energy Display* that will depict the actual heating and cooling system used by the GEO CENTRE. Longer term plans (to be facilitated by the success of GEO's active and ongoing fundraising efforts) include the possibility of expansion to a second floor where aspects of the biosphere may be the focus. Time, resources and a responsive public will dictate progress toward these future goals.

CONCLUDING COMMENTS

Mr. Johnson was inspired to build the GEO CENTRE. Its edifice and exhibits are ranked by all who visit as world class. But to sustain such a venture requires the commitment, creativity and energy of a broad range of supporters and players. Reference has already been made to the importance of partnerships, with institutions and individuals. Equally important is the dedication of the 11-member Board, appointed by Mr. Johnson to oversee all aspects of the operation of the Johnson GEO CENTRE Foundation Inc. A brief profile of the Board will convey the level of expertise represented by its members, and the important advantage this provides to realizing GEO's vision. As mentioned, the Board includes six members to represent Memorial University under the MAP, and these include senior academics (e.g., a Vice-President and a former Dean) and senior managers (e.g., directors of services). Dr. Alice Collins, the former Dean of Education at Memorial University, currently chairs the Board. Other Board members include GEO's architect, senior executives from the local business community, two geoscientists, a lawyer (and former Lieutenant Governor of Newfoundland and Labrador), and, of course, the founder himself, who serves as Vice-Chair. GEO's Executive Director and Financial Manager are ex-officio (but non-voting) members of the Board.

This brings this snapshot of the GEO CENTRE around to that essential element for its success: the staff and volunteers. Without the application of their talent and time to the GEO mission, nothing succeeds (Fig. 10). Led by current Executive Director Mr. Paul Dean (a geologist and former Deputy Minister in the provincial government), the nine permanent staff members include university graduates in geology, education, biology, archeology and business. Their devotion to GEO is demonstrated every day in the skill, excitement, energy and extra hours that they bring to the presentation of exhibits and programs to GEO's visitors. Ideas for improvement of all aspects of GEO are enthusiastically brought to the Board and/or its committees. The staff also coordinates the role of some 15

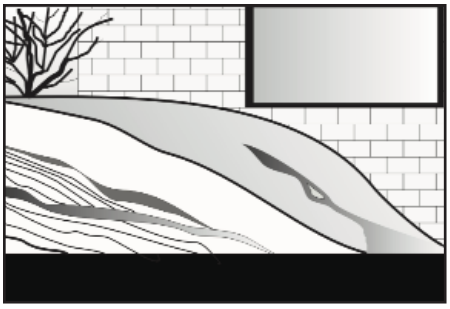
Figure 10. Accomplishing GEO's mission: turned on to Earth science!

dedicated volunteers (many are retired professionals), without whom the breadth and diversity of the GEO program would not be possible. Also, part-time interpreters, many of whom are MUN undergraduates, lead tours and help with classes. Indeed, it is the synergy between staff, volunteers, interpreters and visitors that makes the magnificence of Earth history, as depicted at the Johnson GEO CENTRE, come alive. Ward Neale would be proud! And so will you be when you drop by for a visit the next time you are in St. John's, Newfoundland.

ACKNOWLEDGEMENTS

My colleague and fellow Johnson GEO CENTRE Board member, Professor Jeremy Hall of Memorial University, kindly reviewed the paper and made helpful suggestions for improvement. The GEO CENTRE's Supervisor of Public Programs and Exhibits (and former Supervisor of Education Programs), Mr. Keith Moore, provided information on GEO's education programs, and made available the selection of GEO photos used in the article. And Dr. Paul Johnson is thanked for inviting the author to join the Board of the GEO CENTRE in 2001; it has been a truly rewarding experience.

ARTICLE



Using the Geology of Your Neighbourhood and City for Geoscience Outreach

W. A. Dixon Edwards
Alberta Geological Survey (retired)
Alberta Energy Resources Conservation Board
4999-98 Avenue
Edmonton, AB, Canada, T6B 2X3
E-mail: DixonEd@shaw.ca

SUMMARY
Most Canadians live, work and attend school in urban areas. Your neighbourhood has wonders such as snow-bank stratigraphy, sidewalk sedimentology, and building stone. Urban fieldtrips require little money and little time to run and they can inspire participants. An inner-city school teacher confirmed my belief in urban fieldtrips when she said, "I've never been able to take my students anywhere but we can now take a city bus downtown and see the world. Thank You!" So open your eyes to the grand world of geology around you. Take others on a neighbourhood trip; you will inspire, motivate and educate them.

SOMMAIRE
La majorité des Canadiens vivent, travaillent et étudient en milieu urbain. Votre voisinage même offre des occasions d'émerveillement comme des exemples de stratigraphie de bancs de neige, de sédimentologie des trottoirs, et de pierres de construction. Les excursions urbaines sont peu coûteuses, prennent peu de temps et peuvent s'avérer stimulantes pour leurs participants. Une enseignante d'une école en milieu urbain a confirmé mes idées sur les excursions urbaines lorsqu'elle a déclaré, « Je n'avais jamais pu sortir mes élèves, mais maintenant, nous pouvons prendre l'autobus et voir le monde, grâce à vous. » Soyez donc à l'affût de l'univers géologique qui pointe dans votre milieu. Amener les gens de votre entourage en excursion; vous les aurez intéressés, motivés et éduqués.

INTRODUCTION: YOU CAN INSPIRE INTEREST IN GEOLOGY
Most geologists find the study of geology stimulating and a consuming livelihood. Why should you take time away from your career to get involved in outreach? Think back to the event or person that first inspired your interest in geology. I was enthused over finding red (garnet) and black (magnetite) bands on the Lake Ontario beach near my home when I was four. I was curious about the lumps of coal I unearthed in my backyard when I was eight. With no one to share and encourage my discoveries, these events lay dormant in my mind until, accidentally, I enrolled in a first year geology class taught by Peter Peach at Brock University. Through his stories he turned geology into mysteries. He rekindled in me that creative desire to understand the world around me. My outreach activities keep this thrill of discovery alive and fresh for me; every twinkle in a child's eye or slow smile of recognition in a senior brings a visceral satisfaction. If you enjoy encouraging a child's interest in the pebble they found, motivating a teacher to tell their class about geology, or arousing the curiosity of a senior about the world at their doorstep, then you will relate to why and how I put outreach into practice. Take the time to feel good, try a small outreach activity. If you feel good about the activity then you will inspire, motivate and educate.

LACK OF MONEY, LOCATION, TIME OR SPECIALIZATION IS NO OBSTACLE
People seem impressed by the incredible places and extraordinary events that were part of my job as a professional geologist: commanding a helicopter, finding gold, watching the sun set over an unspoiled lake or getting stalked by a timber wolf. Of course, it cost my company a lot of money and resources to get me to these places and to keep me there long enough for that timber wolf to find me. If you have the resources and time to take groups or classrooms into the wilds for an extended period it would be an incredible experience. On a handful of occasions I was able to take groups of a dozen teachers through the mountains for intensive, week-long fieldtrips during the summer. These trips required budgetary support from EdGEO, a registration cost to each teacher of over $300, and major support from my organization for my time in preparing and delivering the workshops. I have also led hundreds of people, including teachers, geologists, government workers, and seniors, on urban fieldtrips (walks) ranging from one to four hours, at a cost of bus fare and a half day of my time for preparation.

Participants on my long road

trips and urban fieldtrips were asked to complete evaluation forms. In perusing them I noticed similarities beyond the normal 'wonderful experience' and 'very educational' responses you get for any volunteer activity. Certain things elicited recurring, amazed and specific comments from participants, *e.g.* going behind the scenes at the Tyrrell Museum, seeing large fossils in building stone, and panning gold from the North Saskatchewan River in downtown Edmonton. As an organizer and leader of geological fieldtrips, it can be disconcerting to realize that the things that inspire people may be right around the corner. Sometimes, a seemingly small effort can be nearly as positive as a major activity and the little trips can reach, literally, hundreds more individuals at a tiny fraction of the cost. You can run an inspiring workshop with little money, limited time, and right in your own backyard (Fig. 1).

Some geologists are reluctant to lead a fieldtrip or workshop because it may cover topics they have not studied since they were at university. Over my thirty years of public lectures, workshops and fieldtrips, questions were posed that I could not answer, but in only one instance did a participant know much more about the topic. He was a grade three student in my son's class whose granddad operated a rhodochrosite quarry. This eight year-old expert kindly described the mineral for us and presented me with a polished specimen that I have to this day. I have had the pleasure of receiving assistance from professional experts in paleontology, mineralogy, structural geology and stratigraphy on some of my fieldtrips. Although it was reassuring for me to know that the information delivered was accurate and cutting edge, I sometimes found myself acting as translator between the specialist and the group. As leader, I had formed a bond with many of the participants that depended more on my ability to communicate at an appropriate level than on my qualifications. It was also apparent that participants were more often inspired through observation and activity than by a lecture; for example, I knew that they really recognized gold flakes or saw a pattern take form as a fossil when their faces would break into smiles and they would grab their partner to pass on their discovery.

Figure 1. The obvious geological features of Edmonton are the North Saskatchewan River (gold, landslides, outcrop) and the buildings (building stones from around the world).

GEOLOGY FOR EVERY CANADIAN

Most Canadians live, work and attend school in urban areas, and, except for an occasional foray into the wilderness, this is my environment as well. Some years ago I would walk my dog, Sammy, through my neighbourhood in Edmonton. Sammy did not walk fast, so I began to notice geological features and processes. Many of these were ephemeral so that there was always something new to see. Winter and spring hold some special geological treats. It is a great time for public education because this is often considered off-season for work and activities in the natural environment by both geologists and teachers.

Before Sammy took me for walks, I thought people had to travel to observe geology. Now I realize that geology is alive and well right here in my neighbourhood and city. It surprised me to learn that many of my geological colleagues never noticed the stone in the buildings they walked by daily and had never panned gold from the North Saskatchewan River only six blocks from our office. I guarantee you will find geological wonders in your city. Following are some of my neighbourhood favourites.

Geology in your Neighbourhood

Did you ever notice the layers in natural snow banks and speculate on how these relate to specific events? A snow bank is an effective way to explain and illustrate stratigraphy and time; it presents an opportunity to run long or short, natural or artificial experiments. Figure 2 shows the snow bank I built behind my deck. At the end of each snowfall or load of snow, I spread a common colourful material over the surface: I used ground coffee and cinnamon, dried chives and chili powder. I recorded the date and time each powder layer was deposited. At the end of the experiment I cut a core into the snow bank, and then cut the snow bank in half. In both the core and the

Figure 2. Snow bank with, from bottom to top, coffee, chives, chili and cinnamon layers.

section I observe the stratigraphy and was able to create a time scale. Sammy helped me discover an outreach bonus, snow-bank tectonics. A few days after cutting into the snow bank, I discovered a block containing layers lying at the base. It either fell naturally or Sammy jumped on the snow bank and dislodged it. I was able to correlate the layers in the block with the snow bank. I recognized that the block was overturned and reconstructed the motion of the block.

The spring is a wonderful time to observe miniature fluvial features formed by running water released from melting snow. Over a week I observed small deltas form in a gutter where meltwater flowing down a sidewalk cascaded over the curb. Upon close inspection I observed that the deltas seemed to have a characteristic shape and sediment distribution: the plunge-pool had the coarsest sand, the delta top and mid-face exhibited the finest sand, and the delta toe contained an intermediate size (Figs. 3A, B). Curiosity and the challenge of a mystery got the better of me. What was the source of the sand? I sampled the parts of the delta, a miniature channel bar up the road (upstream) from the deltas, as well as ripplemarks on the sidewalk. My sampling confirmed my observations; there were three specific sizes of sand in the deltas and the toe had a bimodal distribution. The medium sand also was found in the bar up the road and correlated well with the sand spread by the city on the streets. Coarse sand was applied at the icy intersection just upstream from the deltas. Fine sand was used on the sidewalk, formed the ripplemarks there, and was carried by water down and into the deltas. The sand in the deltas had a three-fold source, mystery solved.

Snow bank stratigraphy, sidewalk sedimentology and dozens of other processes and features found in the neighbourhood probably would not inspire a senior citizen but it may be just the thing to arouse the curiosity and inspire a grade school student, especially if the experiment takes place right outside their home or school.

Geology Downtown

In the 1990s, I was asked to help with

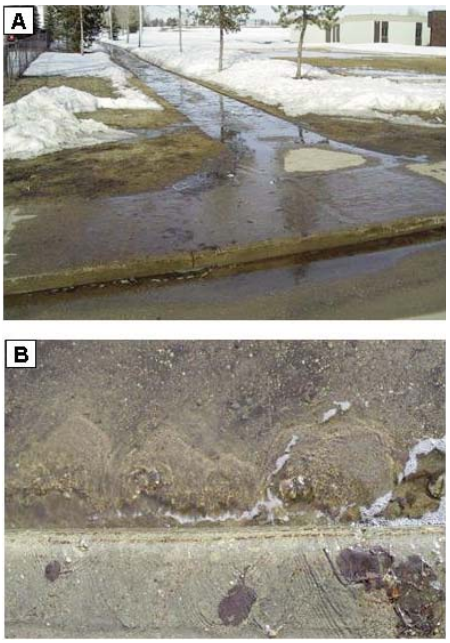


Figure 3. A. Sidewalk meltwater carrying fine sand entered the gutter, where water carried coarse and medium road sand. Small deltas formed from the three types of sand. B. These deltas had a shape and grain size distribution consistent with the water flow and sediment size availability.

the development of the geology section of a new Grade 7 textbook. The editors were largely unaware of geological examples from Alberta and were struggling to provide society-science examples as part of the Science-Technology-Society (STS) model they were using. Fortunately, as an industrial minerals geologist, I live an STS life (discover a deposit, mine and process it, and make a product for society). At that time I recognized a proverbial gold-mine for my urban outreach field-trips: building stone.

At a single intersection in downtown Edmonton (101 St. and Jasper Ave.) we can observe sedimentary, igneous and metamorphic rocks. The stone that enthralls almost everyone is the Tyndall Limestone, which contains a plethora of large fossils. The igneous rock in the Empire Building contains very large, zoned feldspar crystals and a third corner contains spectacular banded gneiss from Minnesota (Fig. 4). Within two blocks of this intersection we can see a beautiful polished slab of sodalite with blebs of magnetite that can stop a speeding magnet (Fig. 5) and several examples of

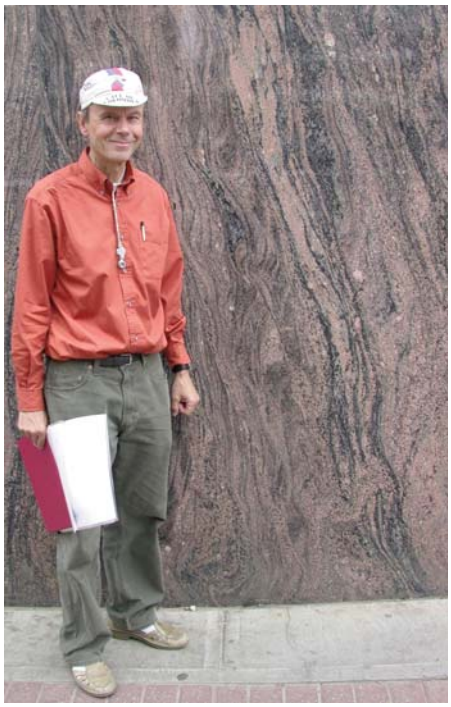


Figure 4. This banded gneiss is superb for discussion of colour, style, building techniques and tectonics. One of the author's outreach partners, Dr. W. Langenberg, is a structural geologist and loves this building.

Figure 5. A mixed group of teachers, geologists and children slide magnets across this polished rock slab to find the blebs of magnetite. Sodalite gives the rock a blue colour.

Indiana Limestone that even some geologists assume, at first glance, to be artificial. Indiana Limestone is the stone used for the carvings we see in a number of downtown Edmonton buildings.

This menagerie never fails to excite the group. Someone almost always says they will never walk by a building again without noticing the stone. I have had requests for tours for teachers' conferences and seniors groups and even geologists. A building

stone walk is a wonderful resource to supplement rock, mineral and fossil workshops. Building-stone tours are excellent for busy people; I have led effective tours in as little as forty-five minutes and they can even be done inside downtown malls. The stone provides a connection to the building itself and a link to history and architecture that in itself is of interest to many people and provides another dimension. One comment I received from a teacher at an inner-city school confirmed my belief in urban fieldtrips and made my effort worthwhile: *"I've never been able to take my students anywhere but we can now take a city bus downtown and see the world. Thank You!"*

Special Geology in your Town

Every city or town across Canada will contain or be near a geological feature that makes it special. It may be a rock outcrop, a beach, fossils, or in the case of Edmonton, a river filled with gold. For many years I have taken groups of teachers, geologists, friends or family down to Emily Murphy Park in the heart of Edmonton to help them pan gold (Fig. 6). I absolutely guarantee them gold. They look very sceptical. In about a minute I pan down a shovel full of gravel and show them the gold flakes. Now I have their undivided attention. I demonstrate how to pan, give them a pan and turn them loose. After that we begin to work our way through their small case of gold fever.

Depending on the time we have available for the workshop we can collect the gold (plus garnet and magnetite) in a small vial using a snuffer bottle and a magnet and even look at the beautiful little mineral grains under a lens or microscope. It is a great opportunity to describe the specific gravity of minerals, how this makes gold panning possible, the origin of the various minerals and their use while we are having a picnic lunch.

Edmonton has a long history of gold prospecting and production. Prospectors discovered placer gold in the sand and gravel of the North Saskatchewan River in the mid-1800s. By the turn of the century there was an active industry in the Edmonton area that included as many as a dozen large dredges. In fact, we still have commercial production of placer gold as a by-product of the gravel mining operations just northwest of Edmonton. Every spring flood brings a new layer of flour gold and amateur prospectors and recreational gold panners always strike it rich.

Figure 6. A. The author explains to a group of planners and environmentalists how to pan gold. B. A typical pan with lots of magnetite, garnet and quartz and anywhere from 10 to 125 flakes of gold.

Placer gold was one of my research topics at the Alberta Geological Survey, so the technical aspects of panning and the geology surrounding it are easy for me to describe. But, you do not have to be an expert to demonstrate gold panning. My father came for a visit when he was 75 and I took him panning for the first time at Emily Murphy Park. In a matter of minutes he was hooked and happily started to pan on his own. When I turned around a half hour later, he was explaining to some 'tourists' how you pan gold and showing them his gold flakes. As they walked away I overheard one of the couples commenting how fortunate it was to run into an old prospector who could tell them all about the placer gold. With enthusiasm, confidence and a smidgeon of knowledge, you can instruct and encourage others.

GETTING STARTED

It is easy to get started on a local outreach project. Take a walk through your neighbourhood or downtown, along the river, by the shore or across a park. Keep your eyes open and look for geological wonders. When you see them, and you will, take some notes and photos. Think about the site or process and perhaps check for literature that can provide background. If the site is open to collecting, you may even do your own investigation.

The site may be interesting enough to be the focus of a single visit or workshop, or you may put a number of sites together as a walk or tour. Choose a broader geological process or topic that is illustrated at the site or sites, and you have an outreach or public education activity.

You can gauge the potential interest in the activity by monitoring the enthusiasm of your friends or family when you take them to the site or on the walk. When you are confident about your activity, approach the principal or teacher at a local school, a science consultant in the school system, a scout leader or anyone else that is a contact for a group ripe to learn about geology!

You will have a readily available fieldtrip site. You will be an instant expert. You will discover others interested in the topic and find that there are support groups (CGEN and local geological societies) and even grants available for materials (EdGEO). You will feel good about your activity. You will inspire, motivate and educate. All because you took a walk with your dog and opened your eyes to the wonderful world of geology that is around us all.

ARTICLE

The Waterloo Earth Sciences Museum

Peter I. Russell
University of Waterloo
200 University Avenue West
Waterloo, ON, N2L 3G1
E-mail: esmuseum@uwaterloo.ca

John E. Motz
University of Waterloo
200 University Avenue West
Waterloo, ON N2L 3G1

SUMMARY
The University of Waterloo's Earth Sciences Museum was started as a Canadian centennial project and has been part of the Department of Earth and Environmental Sciences outreach program for over 40 years. Museum initiatives include lectures; hands-on geological activities such as gold panning; construction of a rock garden; production of geology-themed books for children and adults; podcasts; and participation in gem shows, groundwater festivals and other public events. The museum benefits from public and private funding and the donation of specimens. Volunteers and co-op students allow it to function with a minimum of staff. It provides examples of the types of programs to increase public geological knowledge and understanding that can be offered by even a modest museum.

SOMMAIRE
Le Musée des Sciences de la Terre à l'Université de Waterloo était un porjet du centennaire duCanada, et depuis a fait parti d'un programme de communication du Département des Sciences de la Terre. Les initiatives incluent des conférences; des activitiés géologiques, comme le lavage de gravier pour séparer de l'or; le développement d'un jardin de rocaille; la production de livres à thèmes géologiques pour enfants et adultes; des programmes pour iPod; et la participation à des exhibitions de pierres précieuses, des festivals de l'eau souterraine et auters activites publiques. Le musée jouit de financement publique et privé, et de dons spécimens. Des bénévoles et des étudiants permettent le fonetionnement avec le minimum d'employés. Ceci offert des exemples de programmes pour améliorer les connaissances st la compréhension de la géologie pour le grand publique qu'un musée de taille modeste peut amener.

INTRODUCTION
Since it was started as a centennial project in 1967, the University of Waterloo's (UW) Earth Sciences Museum has become the centrepiece of the UW Department of Earth and Environmental Sciences' outreach program. It attracted an estimated 85 632 visitors in 2008, including 7137 visitors in 134 tour groups, and logged 17 068 hits on its website in 2007. Attendance has shown steady growth, with numbers up substantially from 9252 visitors and 3520 website hits in 2002. The museum is located at the UW Centre for Environmental and Information Technology (EIT) building, in the March Networks Exhibit Atrium and an adjoining gallery space.

Tour groups are generally children from schools or clubs. They can participate in talks on dinosaurs or volcanoes, and hands-on activities, such as a fossil-fish excavation or scavenger hunt. Other museum initiatives include *Rock Around Town* podcast tours of area cities; *Dining with the Dinosaurs*, which gives organizations and groups the opportunity to host functions amongst museum displays; an extensive outdoor rock garden featuring large specimens from Canada and the United States; and books about Manitoulin Island geology and groundwater.

The museum benefits from first-rate facilities as a result of the EIT building's design, but in other ways it can also serve as a model for geological museums housed in more modest venues at other universities and institutions. Staff numbers are minimal, and most activities and administrative work are conducted by the curator, with assistance from volunteers and students on co-op work placements. The operating budget is small (approximately $125 000), and most acquisitions are through donations of funds or artifacts.

HISTORY
Conceived as a Canada centennial project, the UW Earth Sciences Museum was founded in 1967 as The Biology−Earth Sciences Museum, and opened to the public in 1968 (Fig. 1). Funding was provided by the University of Waterloo and the Ontario Ministry of Culture. It was initially housed in two rooms with a total floor area of 280 m^2, in the university's Biology One building. A geological garden was opened in May 1987. It consisted of

Figure 1. The Earth Sciences Museum before moving to the new space in 2003.

23 donated specimens representing various Ontario geological formations. It was renamed *The Peter Russell Rock Garden*, in honour of the museum's curator, in 1999, and now contains over 50 specimens from all over Canada and parts of the United States.

In 1994, the Biology department withdrew its involvement and the museum became known as the Earth Sciences Museum. The museum remained in the original space until August 2003 when it was moved to the newly built EIT building. Curator Peter Russell and Cheryl Atkinson of Teeple Architects were involved in the design of the Exhibit Atrium of the EIT building, so unique facilities, optimized to accommodate museum exhibits, were incorporated into the new structure.

The building's atrium is open seven days a week and houses many exhibits, including a replica *Tyrannosaurus rex* skull, a wall-mounted reproduction *Parasaurolophus* skeleton, various mineral exhibits, and an 8.5 x 1.52 x 0.53 m, 1.2-billion-year-old granite gneiss monolith from the Allstone Quarry in Northern Ontario. There is also a gneiss fountain, which is a schematic representation of water flow through the Great Lakes (Fig. 2). A gallery located adjacent to the atrium (Fig. 3) is the venue for talks to visiting groups and houses more exhibits, such as a replica *Albertosaurus* skeleton, an original cave bear skeleton, and a diorama recreating the environment represented in the Cambrian Burgess Shale in British Columbia. This space is open during regular university business hours.

Figure 2. Great Lakes Fountain in the March Networks Exhibit Atrium.

Figure 3. The Conestoga Rovers Learning Centre.

OUTREACH PROGRAMS

Lectures

Talks to school classes and other groups are the central outreach activity of the museum (Fig. 4). Typically, one to three classes, Grades K to 12, participate in one and a half to two-hour sessions. They are conducted by the curator and the most popular topics are dinosaurs, rocks, and minerals. Interactive presentations to school groups are often followed by hands-on activities, such as excavating fossil fish and a scavenger hunt.

Lectures are also given at external venues as part of life-long learning and public interest programs. These are aimed more at adults than the in-house lectures are, and deal in a more in-depth way with topics such as, *'A Touch of Geology'* (a six-week Life-long Learning course), *'Shirley's Box, The Highgate Mastodon Story'*, and '*Manitoulin Island – Rocks, Fossils, and Landscape of Manitoulin Island'*.

Hands-on Activities

A popular hands-on activity is the fossil-fish dig. This involves using dental picks to carefully excavate fossil fish,

Figure 4. Beaver Group visit.

from rocks of the Eocene Green River Formation in Wyoming. The fossil-bearing limestone is purchased in bulk from Ulrich's Fossil Gallery in Kemmerer, Wyoming [www.ulrichsfossil-gallery.com], at $1 per piece plus shipping. This activity is portable, so it can be taken to gem and mineral shows and other off-campus events.

In the scavenger hunt students are given a list of items to find in the atrium, encouraging them to take a look at the exhibits. Typical questions are: The ice-age elephant is not a mammoth it is a M_S__D_N (mastodon); purple variety of quartz _M_ _ HY_T (amethyst). The 12 questions take Grade 4 students 20 minutes to complete. Older groups have a scavenger hunt without letters to assist in completing the words.

Gold panning is an exciting hands-on activity (Fig. 5) because most people have a touch of gold fever. Materials consist of gold, prepared specifically for panning and mixed with local sand. The gold/sand mixture is then placed in shallow, water-filled, children's swimming pools and panned using commercial gold pans. Gold is purchased at market price, which is expensive; however, the gold is prepared for gold panning at 18 mesh size and is used sparingly, so an ounce lasts a long time. Participants take home one piece of gold taped to a card. To purchase gold for panning, contact Noreen Sailer, Box 39 Dawson, YT, Y0B 1G0, Phone/Fax 1-867-993-5080.

Rock Garden

The Peter Russell Rock Garden (Fig. 6) provides an opportunity for museum visitors to look at rocks in samples larger than typical hand specimens. The 50-plus rocks in the garden are

Figure 5. Gold panning at the University of Waterloo Gem Show.

Figure 6. Peter Russell Rock Garden.

very large, ranging from 50 kg to 5 tonnes, and cover a vast span of geological history, from an Archean banded iron-formation boulder from Timiskaming, ON, to quartzite from Desbarats, ON that exhibits striae engraved by a Pleistocene glacier. The rock garden is also a popular spot for faculty, staff and student lunches and coffee breaks, allowing informal learning to take place.

Gem Show

Each year the Earth Sciences Museum helps host the University of Waterloo Science Open House and Gem and Mineral Show. The event takes place in the March Networks Exhibit Atrium and adjacent buildings. Features include hands-on chemistry, a chemistry magic show, mineral and gem dealers, and displays by area museums, artists and gem and mineral enthusiasts. Invited speakers give public lectures and there are demonstrations of crafts such as rock polishing, gem faceting and polishing, and stone sphere-making. Museum activities such as the fossil-fish dig and gold panning are also offered. The two-day event is typically attended by 1500 people.

Groundwater Festival

The museum also participates in the annual Waterloo Wellington Children's Groundwater Festival. This event features presentations and hands-on educational activities examining such things as the physical science of groundwater; groundwater as a resource; the water cycle; the interaction and interdependence of people, plants and animals with water; an historical perspective on groundwater; and groundwater and the environment. The curator is a member of the advisory board that develops some of the activities used during the event, and participates in the presentation of activities to 4000 children per year. The Groundwater festival details may be viewed at [http://www.wwcgf.com/wwcgf/index.aspx]. The festival is associated with the Children's Water Education Council, which assists 20 festivals throughout Ontario. Details at [http://www.cwec.ca/].

UWaterloosaurus Store

A dinosaur painting was commissioned for the museum and an empty store was made available free of charge at Waterloo Town Square Mall for two months while the painting progressed. Every Saturday for eight weeks the store was open to view with artist Peter Etril Snyder on hand, together with a program of children's art and craft activities, movies and presentations.

Podcasts

Podcasts provide a new way to provide an informal geological education. The museum has a podcast of a two-hour walking tour around Waterloo, titled '*Rock around Uptown Waterloo*,' which allows people to see the various building stones that have been used in their construction. The requisite movie or MP3 files, along with PDF maps, can be downloaded from the museum website. Other podcasts are being prepared, including '*Rock around Kitchener*,' and tours of the museum and rock garden.

Visual Heritage

The museum assisted with geological aspects of visual heritage projects for Sarnia–Lambton and Manitoulin Island. In the Sarnia–Lambton project, Peter Russell described the formation of oil, fossils of the Arkona area and formation of concretions at Kettle Point. Fossils from the area and the diorama of Hungry Hollow fossils were photographed in our museum [http://www.visualheritage.ca/lambton/explorers.htm]. For the Manitoulin project, the curator visited the island and was interviewed at various sites to discuss the geology [http://www.visualheritage.ca/manitoulin/].

Books

The museum has participated in the publication of four books intended to popularize aspects of geology. The first, published in 1993, was the illustrated children's book *Wally & Deanna's Groundwater Adventure to the Unsaturated Zone* (Fig. 7). Written by Leanne Appleby and museum curator Peter Russell, with illustrations and book design by F. Restagno, the book follows the adventures of Wally the Worm and Deanna the Raindrop. Other books in the series are *'Wally and Deanna's Quartz Crystal Adventure'* and *'Blackflies to Blueberries, Wally and Deanna's Wetland Adventure'*. The *Groundwater Adventure* has been translated into Portuguese, French and German. The book has proven popular, and has sold, as of this writing, roughly 10 000 copies in English and over 6000 copies in Portuguese (in Brazil).

Aimed at an adult outdoor enthusiast and naturalist market, *Manitoulin Rocks – Rocks, Fossils and Landscape of Manitoulin Island* is both a field guide to geologically interesting places on the world's largest freshwater island, and an introduction to the geological concepts needed to understand them. It was written by University of Waterloo professors Mario Coniglio and Paul Karrow and curator Peter Russell, and was published by the UW Earth Sciences Museum, in partnership with the Geological Association of Canada

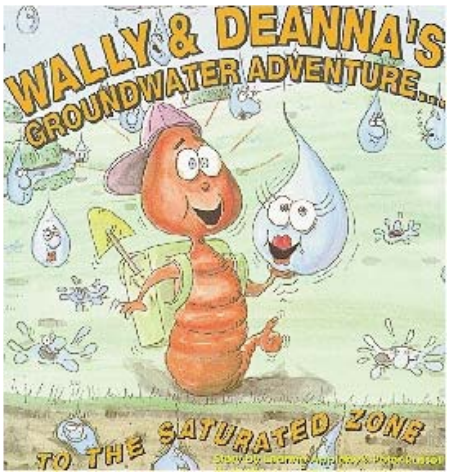


Figure 7. Wally and Deanna's Groundwater Adventure.

Figure 8: Illustration of the box of mastodon bones donated by Shirley Fenton, the subject of the Museum's Highgate Mastodon project, by artist Shiela Karrow.

(GAC) and the Gore Bay Museum in the town of Gore Bay, Manitoulin Island. This book has also been selling briskly.

Donations to the Museum

Donations are a wonderful way to improve the collection and also provide publicity for the museum. Recent successes include the donation of signage for the Peter Russell Rock Garden, and enhancement of our *Parasaurolophus* dinosaur with the addition of a back leg and commissioned artwork. The latter project was also supported by a Canadian Geological Foundation grant. Teeth and a lower jaw tusk of a mastodon from Highgate, ON, were donated by Shirley Fenton of Waterloo (Fig. 8); the donation and accompanying story about this, the most complete Ontario mastodon ever found (now residing in Bismark, North Dakota), were featured in local and international media articles and resulted in many requests for public lectures. Google '*Highgate Mastodon'* and follow the links! Colin Hunter of the Kitchener–Waterloo *Record* received GAC's Yves O. Fortier Earth Science Journalism Award for the best Earth sciences article of 2007 for his story about the mastodon.

Sometimes, world-class specimens are donated to the museum. A few years ago Joseph Sönser of Kitchener, former manager at International Mogul Mine, Silvermines in the Republic of Ireland, donated spectacular crystals he had collected in the course of his job. These important mineral samples were shared with the Royal Ontario Museum. Mr. Sönser's recollections of his career were recorded at the time and add greatly to the value of the collection.

Last September a donation of mining equipment from the Cobalt Historical Society was received. The ore carts, rails and mucking machine will become part of a new mining exhibit using an existing museum tunnel that will be decorated as a mine tunnel. Fundraising is taking place at present for this project.

Monetary donations enable us to purchase collections when they become available. Last December we obtained a collection of dinosaur artwork through partial donation and purchase. Major fundraising also created an endowment for the museum. The Conestoga Rovers Endowment allows us to hire co-op students, provide our programs free of charge to visiting groups, and support other museum projects. A fundraising effort has now started to support a full-time curator.

The Canadian Geological Foundation has been very supportive of our projects, providing funding for the rock garden, purchase of dinosaur replicas, book publishing, and production of a music tape/CD with Chris Rawlings.

Volunteers

Volunteers are a valuable resource for a museum. We have student volunteers from university, high schools, the Kitchener–Waterloo Gem and Mineral Club, and retirees. They assist with the hands-on activities for class visits at gem shows, and Canada Day and Earth Day celebrations. They also assist with writing labels, exhibit text, and the collections database.

POSSIBILITIES FOR OTHER MUSEUMS

Whereas the purpose-built space in the EIT building that houses the museum provides facilities much more luxurious than those available to other small museums, many of the programs and activities are possible on a modest budget. Talks – both in-house and at external venues – rely on media equipment available at most universities and other institutions, and can make use of photographs taken by faculty and staff. The key to success is a knowledgeable and enthusiastic presenter who can bring the material to life and make it accessible to a non-specialist audience.

Hands-on activities, such as the fossil-fish dig and gold panning, can be carried out with modest expenditures. Once again, it is important that the activity is supervised by someone who can put it into a proper geological context so that it achieves more than just keeping participants busy. Podcasts are another way a museum can provide education to the broader community at minimal expense. Using photographs and text generated by museum or institution staff, with the final result available on a website, podcasts provide a

way for institutions with no museum facilities to provide an educational opportunity for the community. Even a rock garden is a possibility for a museum with some outdoor space available. By soliciting donations from local building stone and other materials suppliers, as well as collecting glacial erratics and other local stone, it should be possible to accumulate a collection of rocks that can be incorporated into campus landscaping, and combined with signage to provide some information about each specimen. Participation at local events and activities, such as gem shows and even non-geological events, e.g. Canada Day celebrations, can provide an opportunity for a museum to raise its profile and reach out to people who may not otherwise be exposed to science or geology.

CONCLUSION

Although geological sciences remain somewhat of a mystery to most of the public, an enduring fascination with dinosaurs, especially among children, and a general interest in gems, precious metals and other minerals, attract people to Earth science and provide the means to further learning. Small earth sciences museums are in a good position to capitalize on this by providing opportunities for their communities to take a closer look at geology in an entertaining way. The UW Earth Sciences Museum has been doing this for over 40 years and its success is demonstrated by growing attendance and interest. While other museums will have different resources, the basics of people and specimens are always present and, with a bit of imagination and enthusiasm, can be incorporated into a variety of outreach programs.

ARTICLE

EdGEO: Helping Teachers Teach Earth Science

Eileen Van der Flier-Keller
School of Earth and Ocean Sciences
University of Victoria
Victoria, BC, Canada V8W 3P6
E-mail: fkeller@uvic.ca

Laura Clinton
Director, PDAC Mining Matters
135 King Street East
Toronto, ON, M5C 1G6
Email: lclinton@pdac.ca

Fran Haidl
Saskatchewan Department of Energy and Resources
300 – 2103 11th Avenue,
Regina, SK, S4P 3Z8
E-mail: fran.haidl@gov.sk.ca

SUMMARY
EdGEO is a national program that supports Earth science workshops for Canadian teachers. Geoscientists and teachers work collaboratively to develop and deliver these curriculum-linked workshops, which provide teachers with the classroom resources, enhanced knowledge, and increased confidence to teach Earth science more effectively. Grants of up to $3000 per workshop are available from EdGEO for this purpose. The ability of EdGEO to advance its vital mission relies on the generous support of scientific associations, corporations, foundations and individuals. With increased funding, EdGEO's future will see the compilation of EdGEO lesson plans from workshops across Canada, and the development of learning activities to integrate Earth science into physics, chemistry, biology and mathematics; all these resources will be available for download from the EdGEO web site.

SOMMAIRE
EdGEO est un programme national visant à aider les enseignants canadiens à créer des ateliers en sciences de la Terre. Des scientifiques des sciences de la Terre et des enseignants joignent leurs efforts pour élaborer et présenter ces ateliers adaptés à chaque niveau, dotant ainsi aux enseignants de ressources pédagogiques, de meilleures connaissances pour un enseignement plus sûr et plus efficace. À cet effet, EdGEO offre des bourses pouvant aller jusqu'à 3 000 $. Cela dit, la capacité d'EdGEO à mener à bien sa mission dépend de la générosité de dons provenant d'associations professionnelles, de sociétés, de fondations et de particuliers. Pourvu de meilleures capacités financières, EdGEO entend compiler les plans de leçon EdGEO mis au point au Canada et élaborer des activités d'apprentissage pour intégrer les sciences de la Terre à l'enseignement de la physique, de la chimie, de la biologie et des mathématiques; toutes ces ressources pourront être télécharger à partir du site Internet d'EdGEO.

INTRODUCTION
In 1990, Ward Neale and Louisa Horne published a booklet, *The Past Is the Key to the Future: A Geoscientists' Guide to Public Awareness of Science and Technology*. In this, they note that "Although all segments of society can benefit by an enhanced awareness of science and technology, the area of greatest need is the schools, particularly elementary and junior high schools". These words and sentiments are echoed in the UNESCO 2008 Science Education Policy-making document, where it is noted that, "The fundamental factor in the improvement of students' learning in science and technology is the quality (knowledge, skills and enthusiasm) of their teachers".

What foresight the founders of Canada's EdGEO workshop program [www.edgeo.org] had to develop a national program to encourage locally driven Earth science workshops for Canadian teachers, with the goal of building a geoscience-literate society from the children up. EdGEO does this by providing support for workshops that are developed and led by interested groups of Earth scientists and teachers. These professional development opportunities may include field, laboratory and classroom components. They provide Canadian teachers with the enhanced knowledge, classroom resources and increased confidence that enhance their delivery of Earth science curricula, and grants of up to $3000 per workshop are available from the national EdGEO program.

By providing educational opportunities for today's teachers and, through them, their students, EdGEO seeks to cultivate a heightened awareness of our planet. The expected result is an improved capacity on the part of Canadians to understand the Earth and make informed decisions, especially with regard to the use of mineral and energy resources, the maintenance and remediation of the environment, and

response to geological hazards.

There exists a critical need to provide teachers with training and resources to tackle their Earth science curricula. It is hoped that this article will encourage geoscientists and teachers across Canada to access support from EdGEO and develop local professional development workshops and field trips.

HISTORY

EdGEO was established in the early 1970s by the Canadian Geoscience Council, now the Canadian Federation of Earth Sciences (CFES). EdGEO is coordinated by the Canadian Geoscience Education Network (CGEN), the education arm of CFES. The CGEN is concerned with all levels of geoscience education in Canada and encourages activities designed to increase public awareness of geoscience.

Over the past four decades, EdGEO's leadership has moved across the country. In each new location, dedicated geoscientists and teachers accomplished the organization's mandate with vision and determination. Throughout this time, the mission has remained the same and the program has continued to expand and develop to reach thousands of teachers across the country.

The ability of EdGEO to advance its vital mission relies on the generous support of scientific associations, corporations, foundations and individuals. Support from the Canadian Society of Petroleum Geologists and its Educational Trust Fund, Canadian Geological Foundation (CGF), CFES, CGEN, Geological Association of Canada (GAC), Mineralogical Association of Canada, Canadian Society of Exploration Geophysicists and Geological Survey of Canada (GSC), in addition to several other sponsors over the past three decades, has been critical to EdGEO's ability to serve educators and students across the nation.

The EdGEO web site [www.edgeo.org] serves as a promotional vehicle, helping to achieve program goals through interactive capabilities such as grant applications and reporting forms, and hosts current and past issues of the program's annual newsletters.

EdGEO TEACHER WORKSHOPS

EdGEO teacher workshops are locally driven and are therefore very diverse. They focus on a wide range of Earth science topics, such as geological time, Earth resources, rocks and minerals, fossils or landforms. Some are largely field-based workshops to demonstrate and practice how field activities can be incorporated into Earth science teaching, and others emphasize hands-on activities. Many strive to include both classroom and field components. Workshops attended by local teachers are tied to the provincial/territorial curriculum whereas national workshops emphasize topics common to curricula in multiple Canadian jurisdictions.

An important element of each workshop is the package of resource materials provided to each participating teacher for use in the classroom. The content of this package varies for each workshop but typically includes items such as learning activities, maps, hand lenses, streak plates, magnets, rock and mineral kits, fossil sets, text books, listings of relevant web sites and posters. Such resource materials ensure that teachers have the tools necessary to teach Earth sciences effectively.

Earth scientists and teachers work collaboratively in developing and delivering EdGEO workshops to ensure that the hands-on and field activities and resource materials can be effectively used in the classroom and meet the needs of local teachers. Sessions are inquiry-based and interactive, incorporating practical hands-on activities to help teachers move from theory into practice. The length of these professional development opportunities ranges from two-hour sessions to several days, and can generally accommodate up to twenty-five teachers. Workshops have been presented at teachers' conferences, province-wide professional development days, industry events, and independently.

Organizing committees are urged to solicit funds from local geoscience organizations, service groups and businesses. The EdGEO supplements such funds with grants of up to $3000. Teachers are generally asked to pay a modest registration fee in addition to expenses such as hotel accommodations on field trips. EdGEO grants are intended to help cover the cost of resource packages, field-trip transportation and advertising. Salaries are not covered. Grants are made on the basis of on-line applications that provide a summary and detailed budget of the proposed workshop and/or field trip. Applications are accepted throughout the year. Each is evaluated on its own merits by the national EdGEO executive committee against the established goals of the organization and the monies available.

Applicants are notified within three weeks of submission and EdGEO also proactively seeks enthusiastic geoscientists and invites all interested parties to submit a grant application, ideally several months prior to the planned workshop; EdGEO disburses about $15 000 annually. Many applicants are supported by generous monetary and in-kind funding, resulting in EdGEO requests for support that are far less than the $3000 maximum. Grant recipients are commonly published in the organization's annual newsletter [www.edgeo.org/newsletters.html].

MANY DIFFERENT APPROACHES AND MODELS

Five examples of different workshop approaches from across the country follow.

1. Teaching Basic Geological Concepts and Environmental Geology through Field Experiences

Since 1994, the Nova Scotia EdGEO Workshop Committee has hosted 16, two-day field-based workshops during the month of August (Fig. 1). The workshop moves to a new location each year to ensure this unique professional development opportunity can be accessed by teachers across the province. Although this workshop targets teachers from Grades 3 to 12, over the years it has attracted participation from educators outside the classroom, including volunteer geology teachers from the Nova Scotia Museum of Natural History, employees from the Fundy Geological Museum and interpreters from Parks Canada.

In 2008, field trip leaders from the Nova Scotia Department of Natural Resources and the Geological Survey of Canada (GSC) presented basic

Figure 1. The 12th annual workshop of the Nova Scotia EdGEO Workshop Program included a field trip with a stop at the famous Peggys Cove Lighthouse to reveal key features of the distinctive Devonian granite.

geological concepts such as rocks, minerals, the rock cycle, geological time, plate tectonics, and natural resources during visits to several interesting geological sites. Geology and urban development, acid rock drainage, uranium, radon, radio-nuclides, fluorosis, and the impact of (historical) mining were introduced as key environmental topics. A tour of the Halifax Wastewater Treatment Plant gave participants the chance to consider the issues of sewage, metals, organic contaminants and water quality. An in-class session hosted by the Bedford Institute of Oceanography focused on beaches and the Halifax Harbour. A local teacher also presented a series of learning activities for use in the classroom. All participants received an extensive resource kit including books, maps, posters, lesson plans, videos and popular education materials published by the Atlantic Geoscience Society.

Quotes from teachers:

> *"This workshop was well worth taking. I am inspired, armed with activities and thought-provoking questions to use in class. Thank you so much!"*

> *"I have attended many in-services in the past 25 years. The EdGEO workshops in August and October have by far been the best organized and interesting I have attended. Keep up the good work!"*

2. Connecting Teachers to the Resource Industry in the Field

Teachers from the Greater Toronto Area (GTA) participated in a field-based EdGEO workshop to explore the importance of the geoscape, the three-dimensional relationship between the land*scape* and the *geo*logy below its surface [see http://geoscape.nrcan.gc.ca/index_e.php for information on the Geoscape posters and associated teacher materials across Canada]. Field trip leaders from the Ontario Ministry of Northern Development and Mines, and Prospectors and Developers Association of Canada Mining Matters provided an overview of the geological legacy of the GTA and introduced current geoscience issues of the region. Tours of the extraction, processing, and rehabilitation aspects of aggregate operations (Fig. 2) promoted awareness of the connection between geoscience and the wise use and management of land and resources. On-site, participants studied the importance of aggregates and teamed up to examine environmental problems, concerns, and solutions associated with aggregate operations. Teachers also had an opportunity to collect samples of fossiliferous dolostone, shale and gypsum from aggregate sites. Each field trip stop included the presentation of a curriculum-linked, hands-on activity that could be reproduced in the classroom.

Figure 2. Teachers explore for fossils in Ordovician dolostone at Dufferin Aggregate's Milton Quarry.

Participants received the Geoscape Toronto poster and 24 corresponding learning activities, rocks and minerals from southern Ontario, bedrock and surficial geology maps, the books, '*Toronto Rocks: The Geological Legacy of the Toronto Region*' and '*Rock Ontario*', fact sheets about aggregate production, career profiles for the mining industry, and a card game that focuses on understanding the importance of rocks, minerals and metals in our lives.

Quotes from teachers:

> *"It is opportunities like this that help me deliver the curriculum in a more informative way. My growth helps to translate into my student's growth."*

> *"I enjoyed the day and found it very informative. Superior to any P.A. Day activities I have been subject to. Bravo!"*

3. Participating in Teachers' Conferences

Over 7000 Kindergarten to Grade 12 teachers gathered in Saskatoon and Regina for SHOWCASE 2008, a professional learning conference organized by the Saskatchewan Teachers' Federation. The EdGEO workshop leaders, including two teachers and geoscientists from the University of Saskatchewan, Saskatchewan Ministry of Energy and Resources, Saskatchewan Mining Association, Saskatchewan Geological Society, T. Rex Discovery Centre, Laramide Petrologic Services, and Prospectors and Developers Association of Canada Mining Matters, joined forces to deliver a total of nine two-hour Earth science workshops to over 254 junior, intermediate and senior teachers. All were dynamic classroom-based sessions focused on curriculum connections in Earth science. Lectures, displays, demonstrations, and hands-on activities were used to engage teachers. Five of these workshops focused on an array of topics that included the Earth's crust, rocks and minerals, dinosaurs, fossils, landforms and the environment. Saskatchewan resources were a

major focus in the other four sessions, with expert speakers from Shore Gold, Saskatchewan Potash Corporation and Mosaic Potash.

Teachers returned to their schools with a wealth of resources and materials to enhance their teaching of Earth science and the resource industry. Packages included mineral, rock and fossil posters; fact sheets; Geoscape Northern and Southern Saskatchewan posters; a geological highway map; a wall-size plate tectonic map of the world; and binders with lesson plans, hands-on activities, and background information. Additional sponsorship ensured that every teacher attending the four senior sessions received a complete copy of the resource kit entitled '*Discovering Diamonds*', and in-depth material about Saskatchewan geology and resources. Teachers who attended the sessions were also provided the opportunity to order sponsored rock and mineral kits.

Quotes from teachers:

> *"You're thinking about teachers' needs and classroom preparation – great!"*
>
> *"Excellent hands-on activities to explain the basics of rocks and minerals. Terrific ideas for the classroom!"*
>
> *"This workshop fits right into the science course in Saskatchewan schools"*

4. Creating a Strong Partnership Between Teachers and a Science Network

For over 10 years, teachers have assembled at the Geological Survey of Canada building in northwest Calgary to participate in curriculum-linked workshops designed to equip teachers with the knowledge and resources to deliver the Earth science curriculum with confidence. These workshops form part of an extensive suite of professional development opportunities for teachers offered by the Calgary Science Network. All workshops are jointly presented by geoscientists from the Geological Survey of Canada and by teachers experienced in the delivery of the Grades 3 and 7 Science units – *Rocks and Minerals*, and *Planet Earth*.

The workshops incorporate hands-on experiences with rock and mineral identification, oil and gas drilling simulation, and thrust fault demonstrations (Fig. 3), all of which are intended for use in the classroom. Opportunities to explore book and online resources, including animations and simulations, are invaluable in explaining and demonstrating difficult concepts, such as the cycling of the mantle, or seismic wave movements. The success of these long-running workshops is largely attributed to the collaboration between teachers and geoscientists. When technical understanding is married with pedagogical knowledge, the very best hands-on, discovery-based activities can be implemented and educational resources can be carefully evaluated.

Figure 3. Godfrey Nowlan demonstrates folds and thrust faults.

Teachers bring to the partnership a solid understanding of the teaching profession, knowledge of the local education system, and experience as to what will work and what will not work in a classroom. Teachers are therefore best equipped to develop classroom activities and approaches. They are also well positioned to provide valuable feedback to inquiries from teachers attending the workshop (Fig. 4).

The geoscientist brings to the partnership knowledge of the technical subject matter, its real-world applications and related career opportunities. Teachers, especially those of lower grade levels without specific training in science, benefit from outstanding curriculum-linked, hands-on activities and the experts' descriptions. Teachers of higher grade levels benefit from the career-related information and the interesting and relevant applications of scientific knowledge that can be used as the hooks to stimulate student interest in a topic. The geoscientist can also help provide access to information and expertise in their communities.

Figure 4. Teachers at a Calgary workshop discuss rocks.

Quotes from teachers:

> *"The presenters created an atmosphere of collaborative learning where all teachers were encouraged to share their ideas, successes and shortcomings in addressing this unit with their students and together we became more confident as teachers."*
>
> *"This was wonderful! I really like the "team" aspect – scientist and teacher! Thank you so much. This was better than the teachers' convention!*

5. Engaging Pre-service Teachers before they enter the Classroom

This new initiative, begun in 2005 at the University of Victoria, encourages and supports teachers in training, providing them with the resources, hands-on activity ideas and field approaches, to successfully and confidently teach Earth science in their future classrooms (Fig. 5). An EdGEO 'Education Lab' is offered annually to Education and Pre-Education students at the University of Victoria, as part of a first year Earth science course - EOS 120 Introduction to the Earth System II. The lab accommodates 20 students per year and runs for 11 weekly 3-hour sessions (including an education tutorial). The lab content (which is the same as for non-Education Lab students) includes plate tectonics, minerals,

rocks, stratigraphy and fossils, glacial and fluvial processes and two local field trips. Topics are presented through hands-on activities, experiments, demonstrations, role-playing, literacy activities, and peer teaching grounded in constructivist methods (EDU model – explore, discuss and understand), and transferable to the K-12 classroom. The students receive, and work with, over the course of the labs, resources for their future classrooms, including a mineral kit, igneous, sedimentary and metamorphic rock kits, a fossil set, books, posters, and a lab manual that includes curriculum-linked lesson plans, activity instructions, EDU 'leading question' sheets, and black lines. The 'Education Lab' is co-sponsored by the Pacific Centre for Research in Youth, Science Teaching and Learning (CRYSTAL) an initiative funded by the Natural Sciences and Engineering Research Council of Canada (NSERC), which also supports a longitudinal study to evaluate the impact of the workshop on emerging teacher practices and interest in Earth science teaching. Please contact us if you are interested in setting up a similar Education lab in a first year Earth science course and would like a copy of the lab manual.

Quotes from student teachers:

> *"A fabulous way to present science to people who are interested in teaching. It was a great class."*
>
> *"Almost everything is hands-on or a visual learning experience. It was fun, and that's how learning should be"*
>
> *"I really found this lab to be a lot of fun and very interesting. It made me less intimidated about sciences as this is my first science course ever"*
>
> *"These labs have been very helpful and have made me more confident when I think about teaching EOS in the future"*

WHERE AND HOW MANY

Over the last eighteen years, a total of 179 workshops for teachers have been sponsored by EdGEO, averaging 10 workshops per year across Canada.

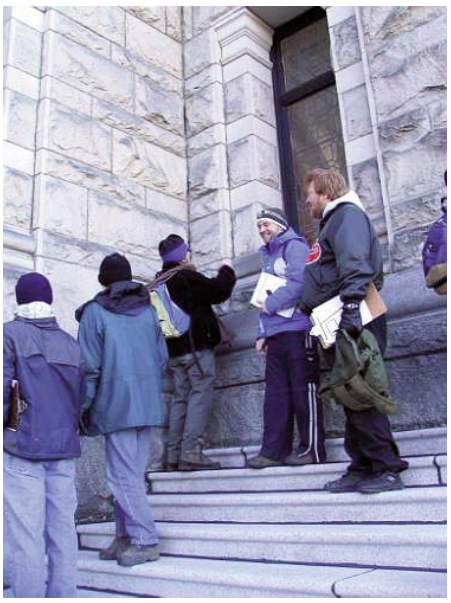


Figure 5. Pre-service teachers in Victoria participate in an urban geology field trip.

The highest number in any year was 22 in 2005. Typically, teacher attendance at an EdGEO workshop ranges from 10 to 30 teachers; however, with the increased delivery of workshops at teachers' conferences in the last few years, such as those in 2008 in Saskatchewan and British Columbia, up to 50 teachers were able to attend a single session.

The numbers of teachers reached through EdGEO workshops is very encouraging – between 1995 and 2008, a total of 3903 teachers attended workshops and received classroom resources, an average of 279 teachers per year. If each of these educators has an average class size of 25, in one year close to 7000 students will benefit from the increased knowledge, enthusiasm and confidence of their teachers as well as the hands-on activities, field trip ideas and resources they bring to the classroom. Over 10 years these 279 teachers will reach approximately 70 000 students.

Although most EdGEO workshops have been based in Nova Scotia, Ontario, Saskatchewan, Alberta and British Columbia, over the last 10 years workshops have also been held in Nunavut, New Brunswick, Québec, Manitoba, the Yukon and the Northwest Territories.

EdGEO applicants are a varied and enthusiastic group whose members represent societies (such as the Calgary Science Network, Atlantic Geoscience Society, Saskatchewan Geological Society and the Pacific Section of the GAC), universities (e.g. Carleton, Victoria, Manitoba), provincial and federal government departments, foundations (e.g. Burgess Shale Foundation), and museums (e.g. Tyrrell Museum), as well as individuals and companies. All are welcome.

WHAT IS THE IMPACT ON TEACHERS?

To date, the assessment of how each EdGEO workshop is received and what the impact is on teachers is determined through evaluation forms completed at the end of each workshop. Participants consistently rate EdGEO workshops as excellent and outstanding. Responses on the evaluation forms suggest that teachers value the hands-on aspect of the workshops, the strong connection to the curriculum, the exceptional classroom resources provided, the field components, the collaborations forged between teachers and geoscientists, and the knowledge gained. Comments also continually make reference to the talented experts who enthusiastically commit to sharing their expertise in Earth science. Very often the teachers comment that the EdGEO workshop is the best professional development they have ever attended.

Although it is known that the teachers value the workshops and with regularity comment that they cannot wait to try the activities and resources in the classroom, we have very little understanding of the longer term impact of EdGEO workshops on teachers or their students. Discussions with EdGEO teacher partners (those involved in developing and delivering workshops together with Earth scientists, and mentoring new teachers) reveal that the benefits are many:

- networking with scientists and other science educators both locally and Canada-wide (e.g. CGEN network, GSC, University, NSERC CRYSTAL, teachers in other districts);
- professional development (e.g. through attending GAC education sessions, CGEN meetings);
- awareness of, and participation in,

provincial and national geoscience initiatives, e.g. activities associated with the International Year of Planet Earth; and
- Enhanced capacity for Earth science curriculum implementation through sharing and development of new activities and resources.

A longitudinal study carried out in conjunction with the University of Victoria EdGEO 'Education Lab' for student teachers shows that emerging teachers continue to use the Earth science activities many years after they have taken the workshop. In addition, a teacher focus group held as part of this study through Pacific CRYSTAL strongly suggests that EdGEO workshop teachers would welcome follow-up support and continued networking to maximize the impact of the initial workshop.

THE FUTURE: NEW INITIATIVES

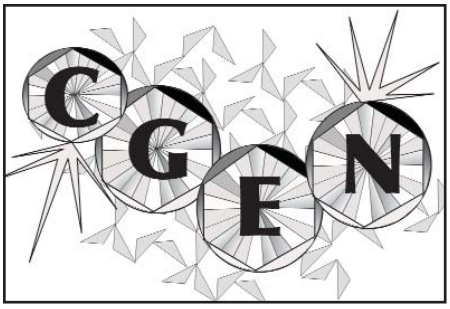
Recent funding from the CGF and GSC has been received to support two new EdGEO initiatives:
- **'Putting the Earth into Science'** takes an interdisciplinary approach to expanding Earth science content in Canadian high schools. Earth Science is often incorrectly perceived as a 'soft' science, usually included as part of geography, and not considered as important as chemistry, physics, or biology. Hence, it is rarely a significant part of the curriculum. The National EdGEO Workshop Program will develop ten curriculum-based lesson plans to integrate Earth science topics into the core subjects of physics, chemistry, and biology. The project will attract teachers of diverse science disciplines, and deliver a meaningful educational experience and important career information to high school students who are largely unaware of how Earth science impacts their daily lives.
- **'Bringing Earth Science to Life'** will deliver a comprehensive collection of relevant, classroom-ready resources in Earth science to junior and intermediate grade levels.

An important element of each EdGEO workshop is the package of resource materials provided to participating teachers for use in the classroom. The contents of this package varies for each workshop, but it typically includes a workshop manual that contains curriculum-linked, hands-on learning activities and the background Earth Science information that supports these activities.

EdGEO will work in partnership with volunteer EdGEO workshop facilitators to compile learning activities, common to curricula across Canada that have been used in previous workshops. The learning activities will be made available for download on the EdGEO web site. The resulting collection will avoid duplication of effort for future EdGEO workshops and leverage existing high-quality learning materials. This project will not only be beneficial to educators, but will also greatly assist volunteer EdGEO workshop organizers by providing materials that can be used directly or adapted for use in new workshops. Facilitator presentation kits for each project will also be developed and made available to interested groups of volunteer Earth scientists and teachers so that the in-service training component for each project can be replicated anywhere in Canada for the National EdGEO Workshop Program.

Future initiatives may also include:
- **Building partnerships with Science Teacher Associations** to host workshops at teacher conferences. Teacher professional development conferences are typically facilitated by national, regional or school district-based teacher associations. By forging relationships with these associations, the EdGEO National Committee and local workshop organizers would be more aware of teacher ProD conference scheduling and could be proactive in offering workshops, keynote talks, support for new curriculum units, or Earth science networking opportunities at events where large numbers of teachers gather.
- **Providing curriculum-linked EdGEO workshops on demand** – EdGEO is examining the possibility of adopting the successful model developed in the United Kingdom [http://www.earthscienceeducation.com/], which offers topic-based EdGEO workshops delivered by trained volunteers, on demand to groups of teachers, individual schools, school districts or other professional development events. A program such as this, combined with the existing local EdGEO workshops, would allow EdGEO's reach to extend to every region of Canada, and would increase the numbers of teachers who could avail of the excellent resources, activities and increased understanding of the important role of Earth science in society, that is delivered by EdGEO workshops.
- **Establishing informal mentoring relationships between Earth Scientists and teachers** to develop and grow the skills, confidence and knowledge needed to help less experienced teachers succeed after attending EdGEO workshops. Mentoring will promote a greater cohesiveness within a regional group of teachers, and potentially provide access to a national community of Earth Science educators.

ARTICLE



Canadian Geoscience Education Network: A Grassroots Powerhouse

Christy Vodden
398 Hinton Avenue South
Ottawa, ON, K1Y 1B1
E-mail: cgen@sympatico.ca

SUMMARY
CGEN was founded in the early 1990s by the Canadian Geoscience Council, and now functions as the outreach arm of the Canadian Federation of Earth Sciences. The need to promote and publicize the earth sciences became clear in the 1980s with growing evidence of science illiteracy among the general public. CGEN, with its goal of raising public awareness of the earth sciences through improving the quality of earth science education and public outreach, has enjoyed explosive growth in the past few years, more than tripling its membership to roughly 300. CGEN membership now includes teachers, writers, artists, museum staff, and others, in addition to earth scientists. CGEN is the focal point for earth science education and outreach in Canada. Through it, people are connecting, developing new partnerships, learning from the successes of others, and sharing information, materials and ideas for teaching and promoting the earth sciences. CGEN supports six core programs, including Careers in Earth Science, EarthNet, EdGEO, Friends of Canadian Geoheritage, Geoscape Canada, and What on Earth.

SOMMAIRE
Le RCÉG a été fondé au début des années 1990 par le Conseil canadien des géosciences et fonctionne désormais comme l'organisme de sensibilisation de la Fédération canadienne des sciences de la Terre. Au cours des années 1980, il est devenu évident qu'il fallait promouvoir et publiciser les sciences de la Terre auprès du grand public, étant donné la faiblesse des connaissances du grand public en la matière. Poursuivant son objectif de sensibilisation du public aux sciences de la Terre par l'amélioration de la qualité de l'enseignement des sciences de la Terre et la tenue d'activités de sensibilisation du public, le RCÉG a connu une croissance fulgurante au cours des dernières années, et le nombre de ses membres a plus que triplé pour atteindre 300 environ. Le RCÉG regroupe maintenant des enseignants, des écrivains, des artistes, du personnel du musée, et d'autres, en plus de spécialistes des sciences de la Terre. Le RCÉG est devenu le carrefour canadien de l'enseignement et des activités de sensibilisation en sciences de la Terre. Par son entremise, les gens créent des liens, développent de nouveaux partenariats, peuvent profiter des succès d'autrui et se partager de l'information, du matériel et des idées pour enseigner et promouvoir les sciences de la Terre. Le RCÉG parraine six programmes principaux dont Faire carrière en géosciences, Géonet, Ateliers EdGEO, *Friends of Canadian Geoheritage*, Géopanorama du Canada, et *What on Earth*.

INTRODUCTION
February 12, 2009, was the 200th anniversary of the birth of Charles Darwin. In the lead-up to it there were all sorts of commemorations and celebrations, but one of the most intriguing was a Facebook site named "Can we find 200 000 people to wish Darwin happy 200th birthday." The site did, indeed, get well over 200 000 people to sign up, through the magic of one person telling a few others and so on and on – and in only 14 days! All in all, a vivid illustration of how powerful these new social networking sites are at connecting people and getting information!

Because the principle is basically the same, it shows why more traditional networking groups like the Canadian Geoscience Education Network (CGEN) can be effective on a smaller scale. CGEN is all about its members sharing information and skills, learning from one another, and helping each other build and promote activities in all parts of the country. The CGEN membership has blossomed in the past few years, from a steady 80 members throughout the 1990s to close to 300 (and growing fast). Consider that each of CGEN's 300 members is connected to his or her own unique network of friends, family and colleagues, and the multiplying effect is potentially immense.

EARLY YEARS OF CGEN
CGEN was founded in the early 1990s by the Canadian Geoscience Council (CGC), and held its inaugural meeting in Edmonton on May 19, 1993. Laing Ferguson of Mount Allison University was its founding chair, and he had the enthusiastic support of many of the

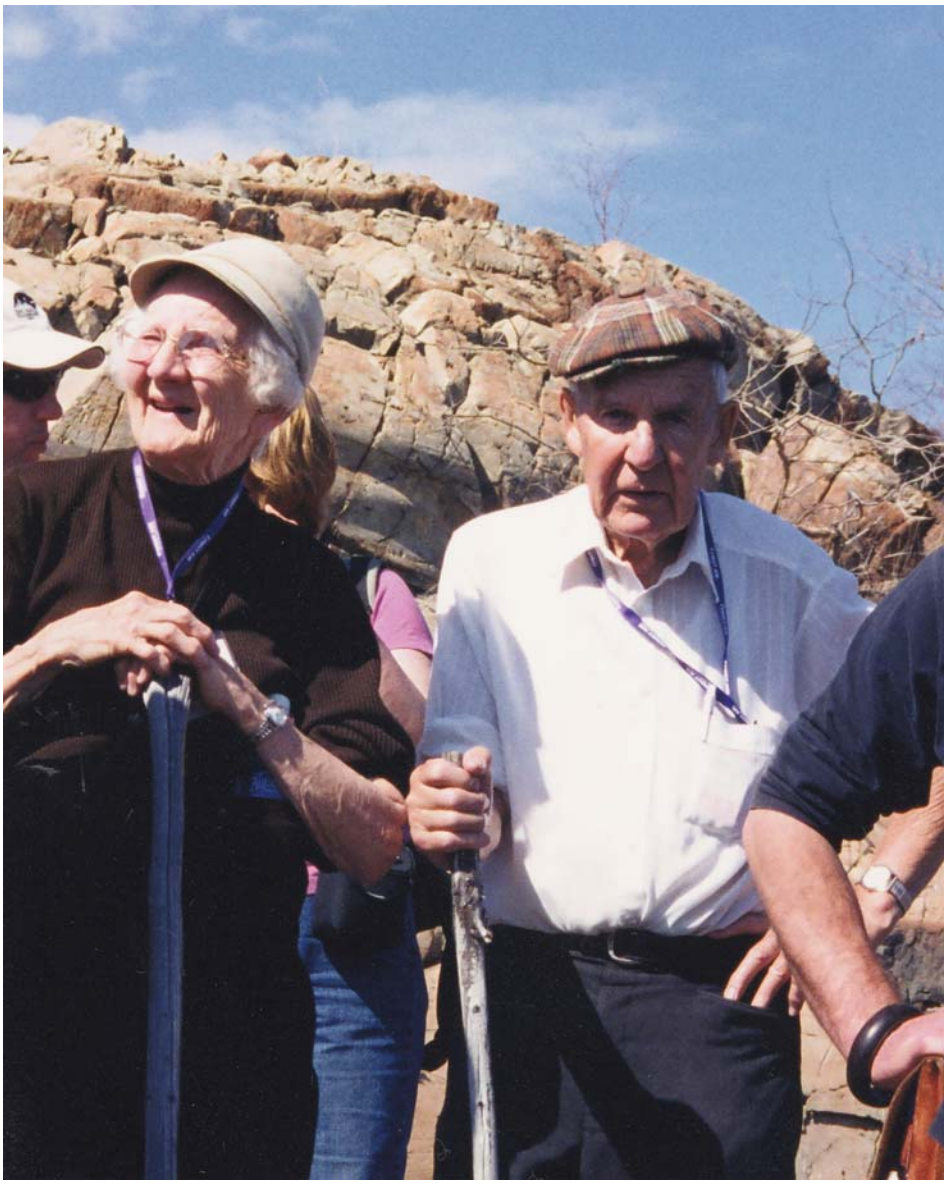


Figure 1: Ward Neale was a strong supporter of CGEN from its founding onward, and he and his wife Roxie were regulars at the CGEN annual meeting. Ward and Roxie attended the Yellowknife meeting, including the superb field trip to Giant Section led by Allan Donaldson. Ward took part in a CGEN regional meeting in Calgary on April 23, and was very much missed at the 2008 annual meeting in Quebec City.

leaders of the earth science community – leaders like Ward Neale (Fig. 1), whose memory we are honouring in this special edition of *Geoscience Canada*. Originally named the Canadian Geoscience Education Board, CGEN's more populist and inclusive-to-all name was adopted within a year of its founding. It is now the outreach arm of the Canadian Federation of Earth Sciences (CGC's successor) and is connected to a wide range of groups and associations involved in earth science education, both in Canada and abroad.

The original intent of the CGC in setting up the Board was to coordinate the outreach and education activities being carried out by the earth science community in Canada. Many excellent initiatives were underway, but they were very much individual efforts scattered all over the country. It quickly became apparent that no one group could set itself up to coordinate such a sprawling suite of activities; rather, what would be really helpful to everyone was a mechanism to share information, ideas and materials – hence the hasty name-change from Board to Network.

RAISING THE PROFILE OF EARTH SCIENCE

The need to promote and publicize the earth sciences was an idea whose time really arrived in the 1980s, with key reports identifying it as a priority for action in all sectors of the earth science community, underscored by influential meetings led by the Royal Society of Canada in 1988 (Science and the Public) and 1990 (Communicating Science: Why and How). As well, a loud and clear wake-up call to all branches of science came from the important and damning 1990 survey on science literacy carried out by the University of Calgary's Edna Einsiedel. It concluded that Canadians, overall, were science illiterates. In days of tightening funding for the sciences, this was a real eye opener and raised many hard questions for earth scientists. Foremost, how were scientifically illiterate Canadian citizens going to make informed decisions on the broad range of earth science-related issues that affect their daily lives?

The move to pare off funds from science to support non-science activities like outreach and education was not immediately welcomed in all camps, but over the years the value of informing the public (aka taxpayers) and the political purse-string holders about the contribution of the earth sciences to the country's bottom line and quality of life won most of the naysayers over. The brilliance of CGEN was that it required next to no funding, and it filled a niche that brought diverse players to the same table to learn about grassroots projects in different parts of the country, and to discuss how they could be adopted or adapted for other regions.

More recently, the bulge of baby boomers going through the employment ranks has raised many red flags, with mass retirements forecast in the next few years that will leave shortfalls in all parts of the earth science workforce. With the earth sciences taught in secondary schools in only a few provinces and territories, and with most teachers in elementary school poorly equipped to effectively teach earth science, where is the next genera-

tion of earth scientists going to spring from? Clearly teachers and their students, from kindergarten to Grade 12, are a critical target group for earth science information and awareness.

Little wonder that CGEN, with its goal of raising public awareness of the earth sciences through improving the quality of earth science education and public outreach, has enjoyed explosive growth in the past few years, more than tripling its membership. There are now CGEN members throughout Canada, and they are involved in promoting the earth sciences to students, teachers and the public (Fig. 2). The demographics of CGEN have altered dramatically as well. Throughout the 1990s, the membership was mostly earth scientists. Now the membership is more diverse, and earth scientists have been joined by teachers, writers, artists, museum staff, corporate outreach specialists, and managers of these programs. This broadening of perspectives has injected greater relevance and dynamism into CGEN discussions and activities.

Figure 2: Over the past few years, a regular feature of CGEN meetings has been hands-on activities showing how best to teach earth science concepts in the classroom. Here, Jennifer Bates (left) and Linda Ham (right) complete a lesson plan on uplift and folding at the 2006 annual CGEN meeting in Montreal.

SHARING KNOWLEDGE AND RESOURCES

CGEN is truly becoming the focal point for earth science education and outreach in Canada. Through it, people are connecting, developing new partnerships, learning from the successes of others, and sharing information, materials and ideas for teaching and promoting the earth sciences. As well, there is a continuing discussion about issues impacting the quality of earth science education and how the CGEN membership can work toward solutions.

CGEN has six core programs that it supports, mainly with leadership commitments, volunteer time and enthusiasm:

- Careers in Earth Science, a website with everything a student needs to make an informed career decision [http://www.earthsciencescanada.com/careers/];
- EarthNet, a virtual resource centre of earth science information [http://www.earthnet-geonet.ca/];
- EdGEO, a national program of workshops about how to teach the earth sciences in the classroom [http://www.edgeo.org/];
- Friends of Canadian Geoheritage, which encourages local groups to help preserve, protect and promote important local geological sites (website in development);
- Geoscape Canada, which produces print and online materials that explain local geology to communities across the country [http://geoscape.nrcan.gc.ca/]; and
- What on Earth, a newsletter about the earth sciences, available at [http://www.whatonearth.org/].

New projects are added as the need arises and resources are in place. For example, the Careers in Earth Science project was developed in 2002 to update an existing brochure and website, in direct response to the forecasts of projected shortfalls in the workforce. Funding was difficult to pin down, but the project took off when it was selected as a flagship activity for Canada's contribution to the International Year of Planet Earth (2007-2009). The result is a website that provides students with everything they need to know to pursue a career as an earth scientist. The English version of the website went live in late 2008, with the French site and a national promotional campaign launched in mid-2009. Publicity, maintenance and updating the website will be an ongoing task for CGEN.

A defining feature of CGEN's core programs is that they each use materials provided by the others. The EdGEO workshops and geoheritage group use the Geoscape products, What on Earth, and EarthNet as teaching tools. Materials developed for Geoscape and EdGEO workshops provide content for EarthNet and What on Earth. The careers website supports the goals of all the other projects, and so on. The combinations and connections among the projects are limited only by imagination.

As a functioning group, CGEN members keep in touch through meetings and an active email exchange throughout the year, including regular information notices sent out by its long-time Secretary-Treasurer, Christy Vodden. CGEN's annual meeting is linked to the Geological Association of Canada's conference in May (Figs. 3, 4), and a winter meeting has traditionally been held in Vancouver. A new initiative is aimed at setting

Figure 3: The 2007 meeting at the GAC–MAC conference in Yellowknife was a seminal event for CGEN. It included an extraordinary outreach session and workshop, organized by Godfrey Nowlan and Donna Schreiner. There were 26 presentations at the session, making it the biggest one at the conference – a historic first! Attendance at the session was a steady 50 or so, peaking as high as 80. The workshop was full, with 35 registrants.

Figure 4: CGEN has been instrumental in building a strong education and outreach component into many of the professional earth science association annual meetings. An education workshop, organized by Charly Bank, Lesley Hymers and Deryk Jackson, at the 2009 Joint Assembly in Toronto, provided professional development opportunities for K-12 science and geography teachers. Shown here is Stella Heenan leading a group through a lesson-plan activity.

up regional meetings throughout the year, all over Canada, hosted by CGEN regional chapters that are just being set up. Everyone is welcome and encouraged to attend any of CGEN's meetings.

CGEN is completely volunteer-run and, like most grassroots organizations, works on a shoestring budget, but is fuelled by the commitment and enthusiasm of its executive and membership. Funding comes from grants from the Canadian Federation of Earth Sciences, and in the past, the Canadian Geoscience Council and Geological Association of Canada. It has also been the recipient of cash awards from The Canada Prize Awards Foundation. An encouraging trend is that some members have started donating speaker's fees to CGEN (Allan Donaldson, head of the Friends of Canadian Geoheritage, has been the trailblazer on this front). CGEN's core projects generally do their own fundraising, with some of them using the CGEN bank account to manage their funds. It does not fund external projects, but it provides support in other valuable ways (its members' time and involvement, publicity through its membership, alerting its members to funding opportunities, letters of support, and organizing workshops and special sessions at conferences).

Membership in CGEN is free to anyone interested in public awareness and education in the earth sciences. Just send an email to cgen@sympatico.ca with "Join CGEN" in the subject line. And for more information, visit the CGEN web site at: [http://www.geoscience.ca/cgen/]

BIBLIOGRAPHY

Clague, J., Turner, R., Bates, J., Haidl, F., Morgan, A., and Vodden, C., 2001, Geoliteracy Canada, a National Geoscience Education Initiative: Geoscience Canada, v.28, p. 143-149.

Nowlan, G., and Schreiner, D., 2007, The State of Earth Science Outreach and an Action Plan for the Future: Geoscience Canada, v.34, p. 49-54.

CGEN Terms of Reference, [http://www.geoscience.ca/cgen/index_en.html#] (click on "Canadian Geoscience Education Network" in "Who we are" box).

CGEN minutes, [http://www.geoscience.ca/cgen/minutes.html].

Canadian Geoscience Council, 1993, Report of the Standing Committees, Canadian Geoscience Education Board, report by Laing Ferguson.

REVIEW

Ghost Mountains and Vanished Oceans: North America from Birth to Middle Age

By John Wilson and Ron Clowes
Key Porter Books
ISBN: 1554700477
Hard cover, 248 p.
Price $34.95 CDN

Reviewed by Eileen Van der Flier-Keller
School of Earth and Ocean Sciences
University of Victoria
Victoria, BC, Canada, V8W 3P6
E-mail: fkeller@uvic.ca

> *"For twenty years, the scientists of the Lithoprobe Project pounded the ground around Canada in a unique seismic survey of our country's lithosphere - the deep crust of rock, tens to hundreds of kilometers thick, beneath our feet. In doing so, they built up a cross section of the country's geology, answering many questions about the geological history of our continent and, by extension, the world."* Quirks and Quarks, May 30th 2009.

From the foreword by Bob MacDonald, to the very last "Sh.., there we were" personal anecdotes from Lithoprobe scientists, this book, which is in essence the story of our science, is a well written, entertaining, and thoroughly gripping read. The book is in part about Lithoprobe and the stories this amazing Canadian scientific endeavour uncovered, but it 'is also a book about wonder'. *Ghost Mountains and Vanished Oceans* is an important book about Canadian science for the public, as it highlights the Canadian scientists who contributed to the rapidly developing understanding of the world as we know it, and provides a fascinating glimpse into how scientific knowledge and understanding move forward.

This is the story of how a thousand or so Canadian scientists sought to understand not just the surface of our amazing planet but 'what's going on below out feet?" specifically within the 200 kilometers of the continental lithosphere. Lithoprobe ran from 1984 to 2005, and combined geological and geophysical techniques to probe the third dimension of crustal geology. The project was funded by the Geological Survey of Canada, the Natural Sciences and Engineering Research Council of Canada, provincial and territorial governments, and industry. Lithoprobe directed its awesome geoscientific resources 'to solve key geological problems in ten specific corridors or transects across Canada" from the 'crumpled fender of North America', the West coast, to the origin of the oldest rocks on the planet, the Acasta Gneiss.

The book is well designed, and arranged by geological age into five parts, each containing a combination of narrative written by John Wilson ("an ex-geologist and frustrated historian") and sidebars with more detailed scientific information written by Ron Clowes (the director of the Lithoprobe project). The fieldwork 'Interludes' are contributed by various Lithoprobe geologists, and add a very human and 'hard-to-put-down' dimension to the text. The black and white illustrations are clear and enlightening, and include actual Lithoprobe scientific images.

Part 1: The Introduction, begins with 'A Vast Jigsaw Puzzle', stories of how our planet has been progressively mapped from Cabot's first sketches of the East coast of Canada, to Smith's earliest geology maps, and finally to Lithoprobe's concern with how 'the pieces of Canada's geological puzzle interact and fit together not only in three dimensions, but also in the fourth: the dimension of time". 'Floating Continents', the second introductory chapter, is one of the best-written and most fascinating accounts I have read of the development of our understanding of plate tectonics, brought to life by stories of people (including the author), of "the most significant paper in the Earth sciences ever to be denied publication", and containing wonderful analogies such as the coffee shop gravity anomalies.

Part 2: Birth to Childhood (4 billion years to 2.5 billion years), takes us to the oldest rocks in Canada, the Acasta Gneiss and the Slave Province, and asks 'Has it always been this way?', pulling together the evidence to answer the question "Just how far back can we push plate tectonics?". This is fascinating stuff! Mini lessons in the sidebars of this chapter include Rocks and Minerals: The Foundation of Geological Studies, The Dating Game, The Slave Province, and The Superior Province.

In Part 3: Tumultuous Teens (2 billion years to 1 billion years), includes chapters 4 and 5. Chapter 4, 'Gluing It All Together' takes us from the Plains of India and the Great Trigonometrical Survey, to indulging in the "endless pleasure to be derived from continuing Alfred Wegener's work in fitting the continents back together". The authors then consider how Australia's motion north into Asia may be a model for the Trans-Hudson orogen, and explain the science that

helps unlock the story of how the North American continent was almost assembled by 1.8 billion years ago. In support of the scientific results of the numerous Lithoprobe researchers, the authors bring in evidence from many facets of Earth Science, including fossils, the atmosphere, and sedimentary rocks, to address the question "It's a great story, but is it true?" Chapter 5, 'Breaking Up', takes us to Africa and our own origins, a 1698 'pygmy' on a ship in London, and the rifts where 'Africa is busily trying to tear itself apart' – possibly a modern analogy to the billion year old Keweenawan rift in North America.

Part 4: Midlife Crisis (the past billion years) includes chapters 6 and 7. Chapter 6, 'False Starts', begins with Scottish and Greek tales of incest and cannibalism, and a young John Wilson's continuing search for rocks and fossils as a starting point to discuss the breakup of Rodinia, the subsequent closing of oceans and formation of Pangaea, and the related glamorous as well as not-so-glamorous causes of change to the progression of life during these last billion years. In this chapter the sidebars include The Newfoundland Appalachians: Exposing the Opening and Closing of Ocean Basins, and a very brief but fascinating glimpse into The Geological Survey: Canada's Oldest Scientific Organization. Chapter 7, 'Our Very Own Mountains', takes us to the West coast, a place where "geology and plate tectonics can (not) be taken for granted", a place where "the lives of thousands of people depend upon our knowledge of what is going on beneath our feet". "In looking at jigsaw puzzles of Earth, we've graduated from a simple Sesame Street puzzle of the world, through a more complex collection of pieces that built Laurentia and the other continents, to the three-dimensional master's puzzle that is British Columbia". The authors introduce us to the 200 or so bits of the West coast puzzle, Lithoprobe images that show the North American prow 'like an extended version of the ramming prows on Greek and Roman triremes", and the records of successive earthquakes related to the Cascadia Subduction Zone.

Part 5: Old Age the next billion years, begins with a quote from Confucius "Study the past if you would define the future", as a start to the final chapter 'A Quiet Old Age? Not Likely'. The authors present some thought-provoking possibilities and future scenarios that play the cycles and processes of the past chapters out into the future. They mention supervolcanoes, more vanished oceans and ghost mountains, and conclude that "things will continue to happen", but that a problem with "predicting the future (as with interpreting the past), is that we can only see what we can imagine".

This book will be a fascinating read for anyone interested in the planet on which we live and how it came to be as it is. As a 'brief history of geology' I would recommend the book for any undergraduate student and my guess is that we will all learn something from this and enjoy the read in the process. Make sure there is a copy in the university reading room, and pass it along to students you know. If you want to give your friends an insight into what you do beyond the stories you may tell over a beer, this is the book. "Mother Earth is a complex old lady"! Find out more - buy your friends a copy or amaze your family with how thrilling the science of our Earth can be.

GEOSCIENCE CANADA

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

September 2009 | VOLUME 36 NUMBER 3 | GSCNA7 36 97-144
Septembre 2009 | VOLUME 36 NUMÉRO 3 | ISSN 0315-0941