

# SERIES



## Geoheritage 3. Attracting Students to the Earth Sciences: An Exam- ple of Individual and Col- lective Outreach Efforts by Industry, Academia and Secondary Education

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### 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.

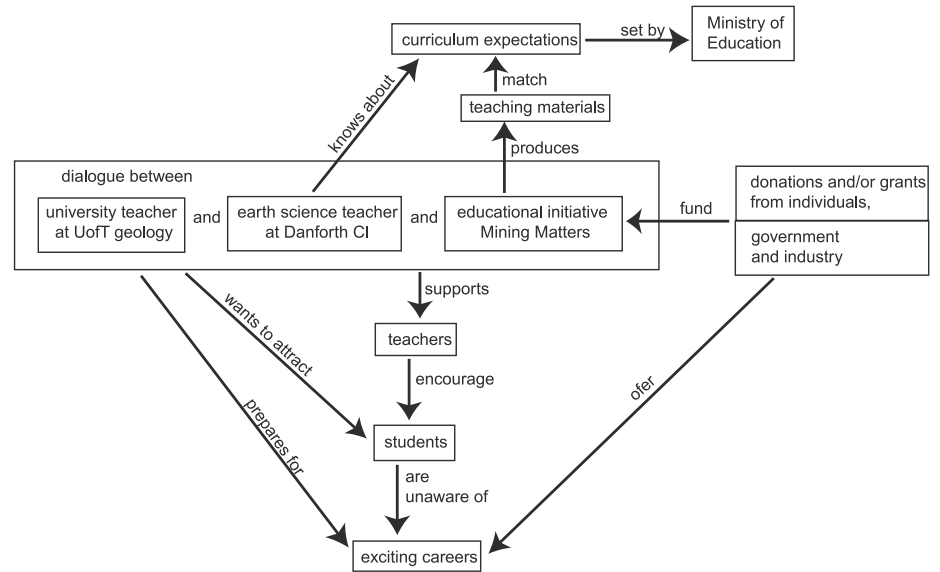
## ABOUT US

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



**Figure 1:** Stakeholders and their connectedness in outreach efforts.

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 education-

al 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.

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