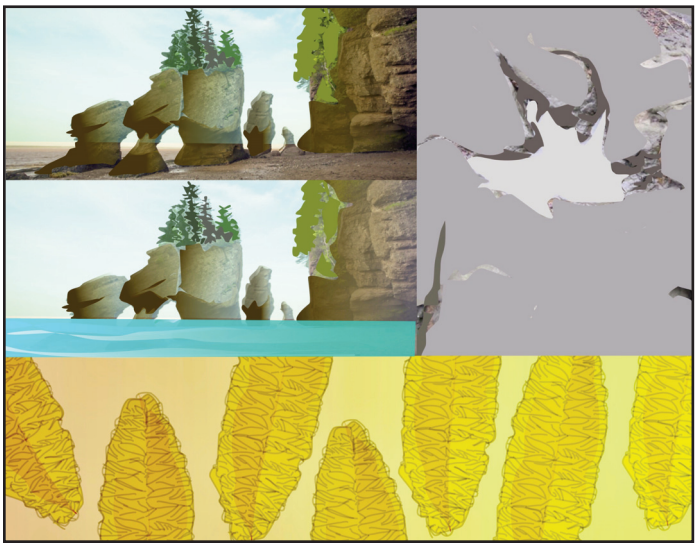
REPORT



Canadian Geoscience Diplomacy in Collaboration with IUGS, UNESCO IGCP Geoparks, and World Heritage Geosites: Past, Present, and Future

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SUMMARY

To commemorate the 60th anniversary of IUGS and the 50th anniversary of IGCP, the 2022 symposium entitled "IUGS, Geoparks, and IGCP – Retrospection, today and the future" was coordinated at the GAC-MAC-IAH-CNC-CSPG 2022 Conference in Halifax (16–18 May) with the companion Cliffs of Fundy UNESCO Geopark field trip (19–21 May). Canadian leadership within IUGS and IGCP includes J.M. Harrison as the first president of IUGS in 1961, Antony Berger's work publishing "*Episodes*", which is the IUGS' quarterly international scientific journal, and Canadian leadership on multiple IGCP projects summarized here. Two panel discussions examined the future of geosciences, UNESCO Geoparks and World Geoheritage Sites in Canada. The need for improved communications with politicians, policymakers, and the general public through education and outreach was emphasized in these panel discussions. UNESCO Geoparks (such as the Cliffs of Fundy), UNESCO World Heritage Geosites and significant museum displays represent vehicles for improving communications with the general public about geosciences and potentially inspiring future geoscientists. This report provides a summary of the symposium and explores some of the many themes that it addressed.

RÉSUMÉ

Pour commémorer le 60e anniversaire de l'UISG et le 50e anniversaire du PICG, le symposium de 2022 intitulé « UISG, Géoparcs et PICG – Rétrospection, aujourd'hui et l'avenir » a été coordonné lors de la conférence AGC-AMC-SNC-AIH-SCGP 2022 à Halifax (16–18 mai), avec une excursion au géoparc UNESCO des falaises de Fundy (19–21 mai). Le leadership canadien au sein de l'UISG et du PICG inclut J.M. Harrison en tant que premier président de l'UISG en 1961, le travail d'Antony Berger dans la publication d'« Épisodes », la revue scientifique internationale trimestrielle de l'UISG, et le leadership canadien sur plusieurs projets du PICG résumés ici. Deux tables rondes ont examiné l'avenir des géosciences, des géoparcs UNESCO et des sites du patrimoine géologique mondial au Canada. La nécessité d'améliorer les communications avec les politiciens, les décideurs politiques et le grand public par le biais de l'éducation et la sensibilisation a été soulignée lors de ces tables rondes. Les géoparcs de l'UNESCO (comme les falaises de Fundy), les sites géologiques du patrimoine mondial de l'UNESCO et les importantes expositions dans les musées représentent des moyens d'améliorer les communications avec le grand public

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sur les géosciences et d'éventuellement inspirer de futurs géoscientifiques. Ce rapport offre un résumé du symposium et explore certains des nombreux thèmes qui ont été abordés.

Traduit par la Traductrice

INTRODUCTION

> *"Science diplomacy: the building and use of international scientific collaborations to identify and address issues facing humanity in the 21st century" (Fedoroff 2009).*

To commemorate the 60th anniversary of the International Union of Geological Sciences (IUGS) and the 50th anniversary of the International Geoscience Programme (IGCP), a group led by K. Boggs organized a Canadian-focused symposium entitled "IUGS, Geoparks, and IGCP – Retrospection, Today and the Future" which was held during the GAC-MAC-IAH-CNC-CSPG 2022 conference (May 15–18) in Halifax, Nova Scotia, Canada (Table 1; Fig. 1). The symposium highlighted the contributions of Canadian geoscience diplomacy towards achieving positive global outcomes, with a specific focus on contributions associated with the United Nations Sustainable Development Goals, as listed in Table 2 (see also UN SDG; sdgs.un.org/goals). The symposium also raised the profile and awareness of IUGS, IGCP and Geoparks within the Canadian geoscience community, and in doing so, aimed to sustain and augment Canadian participation in those organizations. This is a key goal of the Canadian National Committee for IUGS which is co-chaired by K. Boggs and D. Lebel until 2026.

The Halifax 2022 conference was the annual joint meeting of the Geological Association of Canada (GAC) and Mineralogical Association of Canada (MAC). It was organized in partnership with the International Association of Hydrogeologists (Canadian National Chapter; IAH-CNC) and the Canadian Society of Petroleum Geologists (CSPG), now known as the Canadian Energy Geoscience Association. The conference was a huge success, despite the ongoing global COVID-19 pandemic, with more than 800 registrants of whom over 80% participated in person.

The first full day of the symposium (May 16) involved talks related to IUGS and IGCP including general presentations as well as summaries of specific IGCP projects (Table 1). Daniel Lebel, director of the Geological Survey of Canada, opened the session with a presentation highlighting key multi-generational contributions of Canadian geoscientists that advanced global geoscience with new concepts and initiatives over the last 180 years (Lebel and Bobrowsky 2022). These include the Canada-US geology map of America completed by William Logan with American James Hall, Tuzo Wilson and plate tectonic theory, Paul Hoffman and the 'United Plates of America' paper, and other important contributions. Some Canadian geoscientists, such as James Harrison and Digby McLaren, were key founders of the International Geological Congress (IGC) and IGCP, while several others contributed to geoscience education and outreach at the regional, national, and international scales. The day concluded with a keynote presentation by current IUGS president John Ludden regarding the direction that the field of geosciences is headed over the next decade, followed by a panel discussion entitled "The future of geosciences in Canada, IGCP and IUGS". The panel consisted of some of the speakers from that day and involved discussions based on their presentations as well as conversations related to current challenges in geosciences and the future of the field. The following half-day session (May 17) focused on United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Sites and Global Geoparks and concluded with a discussion panel on the "Future of Geoparks and World Geoheritage sites in Canada".

The companion Cliffs of Fundy Geopark field trip, "Telling the story of the Cliffs of Fundy UNESCO Global Geopark, Nova Scotia: linking geoheritage, indigenous heritage and culture", ran from 19–21 May 2022. The field trip was coordinated and led by Caleb Grant (Fig. 2F), the Resident Geoscientist with the geopark, whose personal aim is to "help make the geological wonders in Nova Scotia a little more accessible"; a foundational principle of the UNESCO Geoparks program. The role of the resident geoscientist, and the motivation behind the creation of such geoparks, is to increase connections between the academic community and the public, specifically when it comes to the geosciences. To achieve this goal, we rely on people, such as Caleb, who have a passion for geoscience, education, and communication.

The Cliffs of Fundy Geopark is located in Mi'kma'ki, the ancestral home of the Mi'kmaw nation and strives to honour the oral traditions of their cultural geoheritage. Two scientific highlights of the geopark include the world's highest tides in the Bay of Fundy and the evidence for both the formation and break up of Pangea. Notable field trip participants included John Calder (Fig. 2B), the executive director of the Cliffs of Fundy Geopark and a past chair of the Canadian Geoparks Network, and Godfrey Nowlan (Fig. 2E), the original chair of the Canadian Geoparks Network, who was instrumental in establishing the first Canadian Geoparks (Tumbler Ridge in British Columbia and Stonehammer in New Brunswick; Fig. 3).

This report presents a synopsis of this symposium, and the field trip, as well as background information on the organizations. It is hoped that these efforts will facilitate important discussions regarding the current and future state of geosciences, both in Canada and globally, and will help to create strategies to maintain and increase the relevancy of the field to society in support of the wider goals of the United Nations.

INTERNATIONAL UNION OF GEOLOGICAL SCIENCES (IUGS)

The IUGS is a non-political, non-governmental, non-profit organization that facilitates international cooperation and participation in the field of Earth sciences. IUGS is a member of the International Science Council, which consists of 121 national members representing over one million geoscientists with countries represented through adhering organizations (academies, geological surveys or geological societies; IUGS 2019). Canada has made significant contributions to the IUGS since its inception, including the leadership of J.M. Harrison as

Table 1. Presentations from the "IUGS, Geoparks, and IGCP – Retrospection, today and the future" symposium held at GAC-MAC-IAH-CNC-CSPG Halifax 2022 conference in May 2022 with presenting author emboldened. Talks are listed in order of presentation. The abstracts for each presentation are published in *Geoscience Canada*, volume 49, issue 2.

Day 1 – Monday 16 May

Lebel, D., and Bobrowsky, P., 2022. Canadian contributions to global geosciences: A few key highlights and future outlook.

Berger, A., 2022. Episodes and AGID – Two ventures with Canadian roots.

Henderson, C., 2022. The Permian System: A collaborative effort directed by the International Union of Geological Sciences (IUGS), the International Commission on Stratigraphy (ICS) and the Subcommission on Permian Stratigraphy (SPS).

Laflamme, M., and Schiffbauer, J., 2022. Subdividing the Ediacaran.

Pilarczyk, J., Brain, M., Green, A., Hein, C., Lau, A., and Ramos, N., 2022. From cores to code: IGCP 725's plan to bridge the gaps between geology, process, and numerical modelling to improve forecasts of coastal change.

Adiyaman Lopes, Ö., 2022. IGCP's outreach for 50 years: Evolution from east-west male researcher collaboration to global outreach with gender equality and a perspective for a sustainable future for our planet.

Narbonne, G., 2022. IGCP sedimentary and paleontological projects: 50 years of evolution from "stratigraphic correlation" to "deep-time global change", with a perspective for the future.

Kuiper, Y., Barr, S.M., Haissen, F., Montero, P.G., and Belkacim, S., 2022. The International Geoscience Programme (IGCP): An example and a fiftieth anniversary perspective.

Lesher, C.M., and Barnes, S-J., 2022. IGCP projects 161-336-427-479: Genesis and localization of magmatic Ni-Cu-PGE deposits.

Raymond, J., Blessent, D., Alcaraz, M., Malo, M., Daniele, L., and Somma, R., 2022. Geothermal resources for energy transition: past, present and future of IGCP Group 636.

Chi, G., Fayek, M., Delaney, G., Potter, E., Xue, C., Nie, F., Xu, D., Li, Z., Li., Z., Yi, L., Jin, R., Chen, Y., Song, H., and Xu, Z., 2022. Canada – China collaborative research on uranium deposits: A retrospection and vision for the future.

Bergquist, B., Fernandez, L., Vega, C., Szponar, N., Gerson, J., Nason, K., and Bernhardt, E., 2022. A new program aimed at understanding impacts of artisanal and small-scale gold mining in the Amazon (IGCP project 696).

Ludden, J., 2022. Geoscience for the next decade.

Day 2 – Tuesday 17 May

Calder, J., and Nowlan, G., 2022. UNESCO Global Geoparks in Canada: Their growth, potential, and challenges.

Brink, J., 2022. Head-Smashed-In Buffalo Jump: A UNESCO World Heritage Site in the Porcupine Hills of southwestern Alberta, Canada.

Caron, J-B., 2022. The Willner Madge Gallery Dawn of Life: Exposing the last four billion years of life on Earth at the Royal Ontario Museum.

Kerr, A., and Wylezol, P., 2022. The Cabox aspiring geopark on the scenic west coast of Newfoundland: Where the earth sciences revolution first resolved the tectonic revolutions of the distant past.

Boggs, K., O'Connor, K., Pavelka, J., and Nowlan, G., 2022. The Mackenzie Delta; A potential UNESCO Global Geopark for the future.

McKeever, P., and Narbonne, G., 2022. Geological World Heritage - A revised global framework for the application of criterion (viii) of the World Heritage Convention and a comparison with UNESCO Global Geoparks.

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Figure 1. Presenters from the symposium. (A) Bridget Bergquist describing artisanal gold mining in the Amazon. (B) Daniel Lebel, Director General of the Geological Survey of Canada, characterizing Canadian contributions to global geosciences (photograph by D. Leary). (C) Yvette Kuiper presenting a fiftieth anniversary perspective of IGCP. (D) John Ludden, President of IUGS, announcing the first 100 IUGS geological Geoheritage sites with six Canadian sites mentioned in Figure 4 (courtesy of M. Burgess). (E) Antony Berger providing the history for Episodes and the Association of Geoscientists for International Development (AGID). (F) Özlem Adiyaman Lopes, UNESCO Programme Specialist (courtesy of Yongje Kim). (G) Guy Narbonne presenting "IGCP sedimentary and paleontological projects".

Table 2. The United Nations Sustainable Development Goals (sdgs.un.org/goals).

Goal	Description
1	No poverty
2	Zero hunger
3	Good health and well-being
4	Quality education
5	Gender equality
6	Clean water and sanitation
7	Affordable and clean energy
8	Decent work and economic growth
9	Industry, innovation, and infrastructure
10	Reduced inequality
11	Sustainable cities and communities
12	Responsible consumption and production
13	Climate action
14	Life below water
15	Life on land
16	Peace, justice, and strong institutions
17	Partnerships for the goals

the first President of IUGS in 1961 (Harrison 1978; Histon et al. 2022). Over the last 60 years, Canadian geoscientists served in many other elected positions and provided input on various geoscientific commissions, initiatives, and task groups (e.g. Lebel and Bobrowsky 2022; Narbonne 2022; Henderson 2022). Once every four years, the International Geological Congress (IGC), an international meeting sponsored by IUGS, is organized to promote "*the advancement of fundamental and applied research in the earth sciences*" (www.iugs.org/igc). The next IGC is scheduled for August 25–31 2024 in Busan, the Republic of Korea (www.igc2024korea.org/), where Canada will be delivering a bid to host IGC 2028 in Calgary (www.igc2028canada.org/).

The IUGS aims to facilitate and encourage international cooperation and participation in the field of Earth sciences. The objectives of the organization as defined by IUGS (2019) are:

1. Expanding awareness of the importance of the Earth sciences.
2. Producing authoritative geological standards.
3. Improving the exchange of and access to geoscience information.
4. Expanding geoscience professionalism.
5. Supporting education in the Earth sciences.
6. Addressing human and societal needs.
7. Capacity building.

The IUGS strives to meet its objectives by supporting broad-based scientific activities and programs as well as through the establishment and use of committees, commissions, task groups, initiatives, and joint programs run in tandem with other organizations. Topics supported by the organization include fundamental Earth science research, and economic and industrial applications, as well as social, educational, and environmental geoheritage (IUGS 2019). The IUGS is responsible for sponsoring symposia (such as the one in Halifax), and arranging field visits, as well as addressing issues of standardization as they apply to the field of Earth sciences. IUGS produces a quarterly international science journal called "*Episodes*" which is publicly available and contains original scientific research and review papers, as well as IUGS reports (Berger 2022; www.episodes.org/main.html).

The IUGS also oversees the International Commission on Stratigraphy (ICS) which is the largest and oldest scientific body in the IUGS. The ICS defines and updates global units (systems, series, and stages) for the International Chronostratigraphic Chart that defines the units (periods, epochs, and ages) of the International Geological Time Scale. The commission consists of seventeen subcommissions, each of which is responsible for a specific interval of geological time. Canada hosts thick and aerially extensive deposits of Neoproterozoic sedimentary rocks (the Windermere Supergroup in western Canada and the Conception Group in Newfoundland) and was a major player in a ground-breaking IUGS-ICS initiative to formally subdivide Precambrian strata into geologic periods. These studies resulted in the designation and ratification of the Ediacaran Period (635–539 Ma), the first geologic period ever recognized in the Proterozoic and the first new geologic period of any age named in more than a century (Knoll et al. 2004, 2006). The Ediacaran Subcommission is currently working on attempting to divide the Ediacaran Period into meaningful series and stages by reviewing possible biological, geological, and chemical markers (Laflamme and Schiffbauer 2022). Research on the soft-bodied remains of Ediacaran fauna from Canadian locations resulted in the designation of both the Discovery Geopark and the Mistaken Point UNESCO World Heritage Site in Newfoundland (Figs. 3 and 4, respectively).

The ICS is also responsible for maintaining the international Global Boundary Stratotype Sections and Points (GSSP) registry. Two of the 12 system-level GSSPs worldwide are in Canada: the GSSP for the base of the Cambrian is in the Fortune Head Ecological Reserve in Newfoundland and the GSSP for the Cambrian–Ordovician boundary is at Green Point, Newfoundland, in Gros Morne National Park, a UNESCO World Heritage Site (Fig. 4). Additionally, Crawford Lake in Ontario was chosen in July 2023 as the GSSP for the proposed Anthropocene epoch by the Anthropocene Working Group. Henderson (2022) presented an overview during the symposium of the evolution of the Permian system including summarizing the establishment of the GSSPs for the period.

INTERNATIONAL GEOSCIENCE PROGRAMME (IGCP)

The IGCP (formerly known as the International Geological Correlation Program) is a UNESCO program established and delivered in collaboration with IUGS (Kuiper et al. 2022) whose mission includes "*promoting sustainable use of natural resources, and advancing new initiatives related to geo-diversity, geo-heritage, and geohazards risk mitigation*" (www.iugs.org/igcp; en.unesco.org/international-geoscience-programme). The IGCP was established following the 1972 IGC in Montreal

Figure 2. Photographs from the Cliffs of Fundy UNESCO Global Geopark field trip. (A) Dark grey Triassic North Mountain Basalt overlying red Blomidon Formation playa mudstones, deformed by Cretaceous faulting. (B) John Calder, Interim Executive Director of Cliffs of Fundy Geopark, Past President of Canadian Geoparks Network on Little Dyke. (C) David Piper (Emeritus Scientist, Geological Survey of Canada - Atlantic) with historical fishing weir in distance, standing on the tombolo to Partridge Island (Wa'so'q in Mi'kmaq). (D) Welcome sign to Cliffs of Fundy UNESCO Geopark with the iconic painting of the Three Sisters by Gerald Gloade, a Mi'kmaw artist and current Program Development Officer for the Mi'kmawey Debert Project in Truro. (E) Godfrey Nowlan, Founding Chair of the Canadian National Committee for Geoparks. (F) Caleb Grant, Resident Geologist at the Cliffs of Fundy Geopark standing on Little Dyke Beach (G) Georgia Pe-Piper (Emerita Professor, Saint Mary's University) walking on the beach north of The Old Wife. (H) Vein of the zeolites stilbite (whitish) and chabazite (pink) in North Mountain basalt on the beach north of The Old Wife.

Figure 3. Map showing the location of the five Canadian UNESCO geoparks. (A) Arch Rock at Little Catalina, a triple sea arch that contains Ediacaran fossils, on the Bonavista Peninsula in Discovery UNESCO Geopark. (B) Brook Point in Discovery UNESCO Geopark, near King's Cove on the Bonavista Peninsula (Discovery UNESCO Geopark photographs courtesy of A. Hinchey). (C) Dinosaur footprint from Tumbler Ridge UNESCO Geopark (photograph courtesy of Tumbler Ridge Museum Foundation). (D) Kinuseo Falls, Tumbler Ridge UNESCO Geopark (photograph courtesy of Tumbler Ridge Museum Foundation).

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Figure 4. Map showing the location of Canadian UNESCO World Heritage geology sites. (A-B) Ediacaran fossils from Mistaken Point showing cast of a rock surface showing multiple *Fractofusus* specimens (A) and tactile rock surface cast and 3-D bronze models of common species (B). (C) Cambrian fossils from the Burgess Shale; *Oesia* fossils and 3-D model of the worm living in its tube. (D) UNESCO introductory panels (courtesy of J.-B. Caron). Note that Anticosti Island was inscribed onto the UNESCO World Heritage site list in September 2023 (after submission of this article), making it Canada's newest World Heritage site.

(the last time that Canada hosted the IGC) with the aim of facilitating international cooperation in the geosciences (en.unesco.org/international-geoscience-programme; Narbonne 2022). The IGCP continues to push for maximum international participation and gender equality in accordance with the United Nations' goals. In the early years of the program, projects were typically led by male geologists from the northern hemisphere with co-leaders from less than five countries (Adiyaman Lopes 2022). Participation from developing countries has been historically hampered by language barriers, visa requirements, and a lack of financial support from national governments (Kuiper et al. 2022). Starting in 2012, IGCP began extensive outreach initiatives to increase global representation and gender equality with a focus on developing and under-represented countries. As of 2022, 42% of active project leads and 46% of participants identified as female geoscientists, with 42% of IGCP participants being early career scientists, and 47% from developing nations (Adiyaman Lopes 2022).

IGCP projects are typically funded for five years (Kuiper et al. 2022) and fall within one of five themes: earth resources, global change, geohazards, hydrogeology, and geodynamics (en.unesco.org/international-geoscience-programme; see also Derbyshire 2012; IGCP 2020). IGCP projects that were presented during the symposium are given below as examples for their associated categories, but no projects related to the hydrogeology or geodynamics themes were presented.

Earth Resources – Sustaining our Society

Lesher and Barnes (2022) discussed IGCP #161 (Magmatic sulphide deposits in mafic and ultramafic rocks), IGCP #336 (Petrology and metallogeny of intraplate mafic and ultramafic magmatism), IGCP #427 (Ore forming processes in dynamic magmatic systems), and IGCP #479 (Sustainable use of platinum group elements in the 21st century: Risks and opportunities). These four projects refined exploration models for magmatic sulphide deposits and continue to fuel current research. Chi et al. (2022) summarized IGCP #675 (Sandstone-type uranium deposits) which aims to increase global knowledge of sandstone-type uranium deposits, assess the application of novel techniques in the mining of these deposits, assist with developing guidance for their exploration, and help to facilitate the utilization of uranium in the energy transition (en.unesco.org/international-geoscience-programme/projects/675). Bergquist et al. (2022) summarized IGCP #696 (Impacts from artisanal and small-scale gold mining in the Amazon) which is an ongoing, Canada-led project that studies the release of mercury during such artisanal mining activity and potential health and environmental impacts (en.unesco.org/international-geoscience-programme/projects/696). Raymond et al. (2022) summarized IGCP #636 (Geothermal resources for energy transition), which strives to increase the understanding of geothermal reservoirs while advancing methodologies for characterizing and modelling these reservoirs to ensure the sustainable development of this resource (en.unesco.org/international-geoscience-programme/projects/636).

Global Change and the Evolution of Life

Narbonne (2022) summarized IGCP #588 (Preparing for coastal change), IGCP #639 (Sea-level change from minutes to millennia), IGCP #655 (Toarcian oceanic anoxic event), IGCP #630 (Permian–Triassic climatic and environmental extremes and biotic responses), IGCP #632 (Continental crises of the Jurassic), and IGCP #732 (Language of the Anthropocene). This suite of projects contributed to our understanding of deep time, providing new insights into the magnitude and timeframe of past, present, and future global change.

Geohazards – Risk and Mitigation Assessment for Sustainable Development

Pilarczyk et al. (2022) summarized IGCP #725 (Forecasting coastal change). The primary goal of this project is to enhance the ability to forecast system response to coastal change on a spatial and temporal scale (en.unesco.org/international-geoscience-programme/projects/725).

Other Topics

Additionally, "Special Topics" are defined annually by the IGCP Council and released under particular themes which are considered relevant for society. These include those related to geoheritage, geoparks, geodiversity, the Anthropocene, artificial intelligence applications in geoscience, and the enhancement of societal acceptance for the sustainable development of Earth resources (Adiyaman Lopes 2022). Seed funds from IGCP support projects that benefit society, increase capacity in the geosciences, and promote the advancement and sharing of knowledge between scientists (Adiyaman Lopes 2022; Kuiper et al. 2022). In November 2022 there were 58 active IGCP projects run by 376 ICGP project leaders from 92 countries. Over the past 50 years Canadians have been involved in numerous IGCP projects (see Table 3 for a list of past IGCP projects co-led by Canadians).

Cooperative Projects among Geological Surveys

The Geological Survey of Canada (GSC) is a founding member of the World Community of Geological Surveys (WCOGS), a community of best practices established in 2020 focused on linking these organizations, supporting global sustainable development, and helping develop responses to global issues. The mission and principles of WCOGS overlap with those of IUGS (Lebel and Hill 2020) and capitalized on the success of a special session on the "Changing Role of Geological Surveys" at the 2018 "Resources for Future Generations" conference held in Vancouver, Canada. This eventually led to the publication of a Geological Society of London special volume (Hill et al. 2020). This community of geological surveys will continue to support IUGS, IGCP and other international initiatives through individual or joint contributions. At this point, the WCOGS is focused principally on engaging leaders and staff from member organizations but is ensuring that most of the events are publicly available online. The first few events were initiated at the onset of the COVID-19 pandemic and have increased in frequency and diversity (see www.worldgeosurveys.org for more details and recorded presentations).

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Table 3. Past IGCP projects with Canadian geoscientist co-leaders. Geoscientists not affiliated with a Canadian institution are identified. This list excludes those projects that were presented during the Halifax 2022 symposium. Information from Derbyshire (2012).

IGCP Project Number	IGCP Project Leads	IGCP Project Title	Years
92	A.M. Goodwin	Archean Geochemistry	1974–1983
160	J. Veizer	Precambrian Exogenic Processes	1977–1986
161	A.J. Naldrett	Sulphide Deposits in Mafic and Ultramafic Rocks	1977–1987
171	G.E.G. Westermann	Circum-Pacific Jurassic	1981–1985; 1986–1987
233	J.D. Keppie, R.D. Dallmeyer (USA)	Terranes in the Circum-Atlantic Palaeozoic Orogens	1985–1990; 1991
257	H.C. Halls	Precambrian Dyke Swarms	1987–1991
259/360	A.G. Darnley, J.A. Plant (UK)	International Geochemical Mapping; Global Geochemical Baselines	1988–1992; 1993–1997
290	M. Higgins, J.-C. Duchesne (Belgium)	Anorthosites and Related Rocks	1990–1994
293/386	H.H.J. Geldsetzer, Xu Dao-Yi (China)	Geochemical Event Markers in the Phanerozoic	1990–1993
314	L. Kogarko (Russian Federation), J. Keller (Germany), K. Bell	Alkaline and Carbonatitic Magmatism	1991–1995
315	I. Haapala (Finland), R.F. Emslie	Rapikivi Granites and Related Rocks	1991–1995; 1996
342	M. Zentilli, C. Dtassinari (Brazil), F. Munizaga (Chile)	Age and Isotopes of South American Ores	1992–1996; 1997
353	J.V. Matthews Jr., A. de Vernal	The Last Interglacial Period in the Circum-Arctic	1993–1997
354	P. Rongfu (China), P. Laznicka, J. Kunina (USA), D.V. Rundquist (Russian Federation), I. Plimer (Australia), T. Nakajima (Japan)	Economic Super Accumulations of Metals in Lithosphere	1995–1999; 2000
367	D.P. Scott	Late Quaternary Coastal Records of Rapid Change	1994–1998
371	R.P. Gorbatschev (Sweden), C.F. Gower	North Atlantic Precambrian (COPENA)	1994–1998; 1999
406	M.V.H. Wilson, T. Marss (Estonia), P. Mannik (Estonia)	Circum-Arctic Palaeozoic Vertebrates	1996–2000; 2001
415	J.T. Teller, R. Valkmae (Estonia)	Glaciation and Reorganization of Asia's Drainage	1997–2001
419	M. Wendorfi (Botswana), P.L. Binda	Foreland Basins of the Neoproterozoic Belts in Central-to-Southern Africa and South America	1998–2002
447	X. Meng (China), D.G.F. Long, R. Bourrouilli (France)	Proterozoic Molar-tooth Carbonates	2001–2005
450	S.S. Iyer, A.F. Kamona (Namibia), A. Misi (Brazil), J. Cailteux (DR Congo)	Proterozoic Sediment-hosted Base Metal Deposits of Western Gondwana	2000–2004
453	J.B. Murphy, J. Keppie (Mexico)	Modern and Ancient Orogens	2000–2004
454	O. Selinus (Sweden), P. Bobrowsky, E. Derbyshire (UK)	Medical Geology	2000–2004
463	C. Wang (China), M. Sarti (Italy), R.W. Scott (USA), L.F. Jansa	Upper Cretaceous Oceanic Red Beds	2002–2006
467	M.J. Orchard, I. Krystyn (Austria), J. Tong (China), S. Lucas (USA), H. Campbell (New Zealand), F. Hirsch (Japan), K. Ishida (Japan), Y. Zacharov (Russian Federation)	Triassic Time and Trans-Panthalassan Correlations	2002–2006; 2007
469	C.J. Cleal (UK), B.A. Thomas (UK), S. Oplustil (Czech Republic), Y. Tenchov (Bulgaria), E. Zodrow	Late Variscan Terrestrial Biotas and Paleoenvironments	2003–2007
474	B.R. Coleby (Australia), L.D. Brown (USA), F.A. Cook, G.S. Fuis (USA), R.W. Hubbs (UK), D.M. Finlayson (Australia), S. Li (China), O. Oncken (Germany)	Images of the Earth's Crust	2003–2007
479	J.E. Mungall, M. Ijina (Finland), C. Ferreiro-Filbo (Brazil)	Sustainable Uses of Platinum Group Elements	2003–2007
501	F.J.A.S. Barria (Portugal), W.S. Fyfe, O. Leonardos (Brazil), S. Li (China)	Soil Regeneration with Erosion Products and Other Wastes	2004–2005
502	R. Allen (Sweden), F. Torres (Spain), J. Peter, N. Cagatay (Turkey)	Global Comparison of Volcanic-hosted Massive Sulphide Districts	2004–2008
511	Jacques Locat, J. Mienert (Spain), R. Urgeles (Spain)	Submarine Mass Movements and Their Consequences	2005–2009
514	N. Patyk-Kara (Russian Federation), A.Duk-Rodkin, B. Hou (Australia), L. Ziyang (China), V. Doigopolov (Kazakhstan)	Fluvial Palaeosystems: Evolution and Mineral Deposits	2005–2009
521	V. Yanko-Homback, Irena Motnenko	Caspian-Black Sea-Mediterranean Corridor during the Last 30 ka: Sea level Change and Human Adaptive Strategies	2005–2009
526	F.I. Chiocci (Italy), L. Collins (Australia), M.M. de Mahiques (Brazil), R. Hetherington	Risks Resources and Record of the Past on the Continental Shelf	2007–2011
574	S. Johnston, G. Gutierrez-Alonso (Spain), A. Well (USA)	Bending and Bent Orogens and Continental Ribbons	2009–2013
587	P. Vickers-Rich (Australia), M. Fedonkin (Russian Federation), J. Gehling (Australia), G. Narbonne	Entity, Facies and Time – The Ediacaran (Vendian) Puzzle	2010–2014
600	A. Hou (China), D. Leach (USA), J. Richards, R. Goldfarb (USA)	Metallogenesis of Collisional Orogens	2011–2014

The priorities for the WCOGS Activity Committee for the next few years are nurturing the next generation of talent, geoscience education, linking women geoscientist leaders, collaborating with IGCP, and advancing technical sessions on global earthquake risk reduction, and landslides. The Secretariat organization rotates on a two-year period between member organizations with the GSC hosting the first two years. As of January 2023, the EuroGeoSurveys, a non-profit organization that represents the Geological Surveys of Europe, is the current WCOGS Secretariat and will serve until the end of 2024.

UNESCO GLOBAL GEOPARKS AND WORLD HERITAGE SITES

UNESCO Global Geoparks and geoscience-themed World Heritage Sites are important venues for promoting geoscience while engaging the individuals and families that visit these sites. These venues owe their origin to a 2005 report by the International Union for Conservation of Nature (IUCN) entitled "Geological World Heritage: A Global Framework" (Dingwall et al. 2005) that aimed to assist the World Heritage Convention in recognizing and protecting regions of geological and geomorphological heritage and inscribing such regions onto the World Heritage List (McKeever and Narbonne 2021). World Heritage Sites have "Outstanding Universal Value" which is evaluated using a series of criteria and conditions that cover cultural and natural properties, defined by the UNESCO World Heritage Centre (2019). The key properties that relate to geological features are encapsulated in criterion 8 of 10, which reads:

> *"Be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features"*

The UNESCO World Heritage Committee requested in 2013 and 2014 that IUCN revise the initial Dingwall et al. (2005) report to "*refine the proposed 13 themes, articulate the threshold of 'Outstanding Universal Value', and clarify the difference between the criterion of World Heritage and Geoparks*". At that time, geoparks were not designated by UNESCO but this changed in 2015 when UNESCO adopted the new designation of UNESCO Global Geopark and all pre-existing global geoparks became UNESCO Global Geoparks (McKeever and Narbonne 2021, 2022). McKeever and Narbonne (2021) published the "Geological World Heritage: A revised global framework for the application of criterion (viii) of the World Heritage Convention". This revised report identifies 11 themes (reduced from 13 in the 2005 report) for the evaluation of World Heritage sites that involve key geological properties. These 11 themes are as follows:

1. History of planet Earth and the evolution of life.
2. Tectonic systems.
3. Erosional systems.
4. Volcanic systems.
5. River, lake and delta systems.
6. Cave and karst systems.
7. Coastal systems.
8. Marine systems.
9. Glacial and periglacial systems.
10. Desert and semi-desert systems.
11. Meteorite impacts.

McKeever and Narbonne (2021, 2022) provide guidance and a framework for determining which designation, World Heritage or UNESCO Global Geopark, is appropriate when considering new geological and geomorphological attributes for international recognition and preservation.

Global geoparks are not parks in the traditional North American way of thinking but are instead places to reflect on and celebrate the connections between the land and the people that inhabit it (Calder and Nowlan 2022). UNESCO Global Geoparks are designated, defined geographical regions that have international geological significance, and are managed in the spirit of sustainable development with protection and education programs (en.unesco.org/global-geoparks). They connect the geology of a region with the natural and cultural heritage, to increase awareness of important societal issues such as climate change, resource sustainability, and natural-hazard risk (Calder and Nowlan 2022). Global geoparks combine conservation with sustainable development and are intended to be led by the local community (a 'bottom-up' approach) with the aim of increasing geotourism. As global geoparks focus on both land and people, aspiring geoparks should include Indigenous ways of knowing and culture, with Indigenous storylines presented parallel to the science (Calder and Nowlan 2022). In the Canadian context, geoparks provide opportunities for reconciliation with Indigenous peoples, offering a way to recognize and honour Indigenous culture and connections with the land.

As of November 2022, there are 177 UNESCO Global Geoparks spread over 46 countries (en.unesco.org/global-geoparks), with five in Canada; Tumbler Ridge (British Columbia), Percé (Quebec), Stonehammer (New Brunswick), Cliffs of Fundy (Nova Scotia), and Discovery (Newfoundland and Labrador). These locations are shown in Figure 3, with information at www.canadiangeoparks.ca. It is estimated that the number of geoparks in Canada will double by the end of the decade as several aspiring geoparks are currently working on their applications (www.canadiangeoparks.ca). An example of one such aspiring Canadian geopark is Cabox on the west coast of Newfoundland where the Precambrian to Late Ordovician Bay of Islands Igneous Complex, one of the first ophiolite sequences recognized, enables visitors to walk from ancient intertidal zones, onto the mantle, across the Moho (Kerr and Wylezol 2022). Assessments are underway to identify potential new global geopark candidates in Canada by focusing on regions that are under-represented. This is especially relevant for Canada's North as there are no current geoparks anywhere in the world that are located in permafrost regions. A geopark in the North would offer a unique perspective into the impacts of climate change, specifically with respect to changing permafrost conditions. Furthermore, a geopark in

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Canada's North would ideally be Indigenous-led and directed, ensuring the inclusion and proper representation of Indigenous culture, with the aim of increasing geotourism to the region to benefit the communities. Katherine Boggs spoke on initiatives related to a possible future global geopark in the Mackenzie Delta region, where initial communication with local communities had just started prior to the onset of the COVID-19 pandemic and is soon set to resume (Boggs et al. 2022).

UNESCO is also responsible for the identification and designation of World Heritage sites which are locations that demonstrate "Outstanding Universal Value". There are over 1100 UNESCO World Heritage sites (both natural and cultural) worldwide, with 22 in Canada. Of these 22, nine sites were designated based on geoheritage criteria and represent a cross-section through the geodiversity of the Canadian landscape. The locations of these sites are indicated in Figure 4; more details are available at whc.unesco.org/en/list. Five of these sites (Canadian Rocky Mountain Parks, Dinosaur Provincial Park, the Joggins Fossil Cliffs, Gros Morne National Park, and Mistaken Point) were included in the world's "First 100 Geological Heritage Sites" recently compiled by IUGS (2022).

An overview of the Head-Smashed-In Buffalo Jump UNESCO World Heritage site in southwestern Alberta was presented by Brink (2022) during the symposium. Additionally, Caron (2022) described the Willner Madge Gallery 'Dawn of Life' exhibit at the Royal Ontario Museum (Toronto, Ontario, Canada), which contains fossil specimens from every Canadian province and territory. The gallery includes fossils from five UNESCO World Heritage Sites: Mistaken Point (Ediacaran) in Newfoundland, the Burgess Shale (Cambrian) in the Canadian Rocky Mountain Parks (British Columbia), the Joggins Fossil Cliffs (Carboniferous) in Nova Scotia, Miguasha (Devonian) and Anticosti Island (Ordovician–Silurian) in Quebec. The adjoining ROM James and Louise Temerty galleries of the Age of Dinosaurs contain dinosaur fossils from Dinosaur Provincial Park, also a UNESCO World Heritage Site (Fig. 4).

GEOSCIENCES FOR THE NEXT DECADE

The final presentation on Day 1 of the symposium was 'Geosciences for the next decade' by current IUGS president, John Ludden. His presentation provided context as to why the field of geoscience remains relevant in today's world and offered food for thought as to how this role will develop in the near future (Ludden 2022). Ludden stated that the study of Earth science is critical for furthering our understanding of our planet, for creating and maintaining a safe and healthy Earth, for sustainable development and growth, and for helping to reduce global economic inequalities. Ludden also showed that there are opportunities for geoscience to respond to, and be driven by, current major global societal factors. Examples include energy supply and decarbonization, a need to reduce global emissions, studying the geological risks along with the hazards, population change on a global scale, data science, environmental regulations, and public opinion on such matters. He noted that typical academic geoscience research has the tendency to focus on incremental science (i.e. small research questions with limited visibility) that do not by themselves address global issues. Ludden suggested that geoscientists should be trying to shift to big geoscience initiatives that tackle larger, more pressing problems with better visibility. This trend has gained momentum with geological survey organizations, as exemplified by the GSC, the United States Geological Survey, the Bureau de Recherches Géologiques in France, and other collaborative initiatives by EuroGeoSurveys.

Ludden acknowledged that the field of geoscience faces many challenges in its current state and in moving forward. For instance, progress is hampered by lack of connections between discovery science, applied science, and the translation of science. He observed that geoscientists have become proficient in identifying issues but tend to leave the problem resolution to engineers. Geoscientists must become more adept at communicating with other disciplines and at developing better working relationships, especially with engineering and socioeconomic fields, in order to facilitate and guide future initiatives. The geoscience community needs to develop meaningful strategies to increase enrolment in post-secondary Earth science programs to avert the possible skill shortages that this may eventually trigger. The number of university geoscience departments that are now closing due to diminishing enrollment is alarming (see Nature Reviews Earth and Environment editorial 2021). Furthermore, Ludden stated that there is a tendency for national geoscience policies to look inwards, specifically in regard to mineral resource exploration, leading to global inequities.

An over-arching challenge faced by geoscientists, as described by Ludden (2022), is the climate crisis, which also plays a major role in shaping the future. He reported on the UK-based Hutton Series on Climate Change (2020–2021) that brought together experts, business leaders, scientists, and concerned citizens who identified and defined ten key priorities, innovations, and actions needed to mitigate the climate crisis (www.panmurehouse.org/programmes/hutton-series). The Hutton Series identified several needs that are cross-disciplinary (science, engineering, finance, and citizens) which apply to various levels of government, from the people, to the researchers, to the policy-makers. Ludden (2022) stated that there needs to be a change to the global engineering ethos that prioritizes caring for the planet by developing and testing novel technological solutions. Governments need to provide leadership and policies that focus on long-term sustainability. This will also help to improve investor confidence and encourage citizens to support policies aimed at climate-change mitigation. Ludden further stressed that geoscientists, and geoscience industries, should lead by example for net-zero initiatives, with the aim that these strategies be implemented globally. The technology required to achieve an energy transition largely exists but requires optimization and a significant injection of capital. Furthermore, Ludden emphasized that the finance sector needs to modify its current way of thinking so that it can decouple economic growth from carbon emissions.

DISCUSSION PANELS

IUGS and IGCP Discussion Panel

The first day of the symposium concluded with a panel discussion, following John Ludden's talk, with most of the earlier IUGS and IGCP presenters serving as panelists. Several topics were inspired by the issues raised by John Ludden and are discussed in this section. The main points from each of the panel themes are summarized below, based on the opinions and experiences of panel experts and audience members. These provide some insights into potential issues facing the geoscience community with the aim of initiating further discussions. Various governments, universities, and organizations have already started to develop programs to address some of these issues, but novel ideas and initiatives are needed to ensure long-term, meaningful change.

Communication with Politicians, Policy- and Decision-Makers

There are numerous challenges when it comes to communicating Earth science to policy- and decision-makers in support of the creation and funding of long-term strategies in ever-changing political and economic environments. In Canada, these challenges are further exacerbated for educational proponents as their sectors report to provincial and territorial Ministries of Education which have minimal geoscience teaching in their education programs (geosciences are not even designated as a teachable in Canada). It was suggested that educators and organizations collaborate with government departments (such as the Geological Survey of Canada and Provincial and Territorial geological surveys) who are well situated to influence policy development. For instance, the Pan-Canadian geoscience strategy, which does not include research-granting councils and universities, lists geoscience outreach to the public and decisions makers as a priority. The EuroGeoSurveys strategy, which supports the new Geological Service of Europe project, has similar aims for promoting geoscience and education outreach (EuroGeoSurveys 2022).

Creating Long-Term Strategies and Solutions

John Ludden commented in his presentation that Earth scientists can provide ample evidence of global issues (e.g. the climate emergency) but that they tend to move on to identifying the next issue hoping that engineers will come up with solutions. This led to discussion invoking several newer geoscience programs as examples of how this mindset might be shifting. For example, several cross-disciplinary programs throughout Canada are attempting to develop methods for mitigating the impacts of climate change. They include collaborations between scientists, engineers, and policy-makers across industry, government, and academia in the fields of carbon capture and sequestration, groundwater mapping, geothermal, critical minerals for green energy, hydrogen storage, geohazards, coastal erosion and other topics. Even with these programs, Earth scientists need to do better at engaging other disciplines in order to develop more meaningful solutions to the global climate emergency.

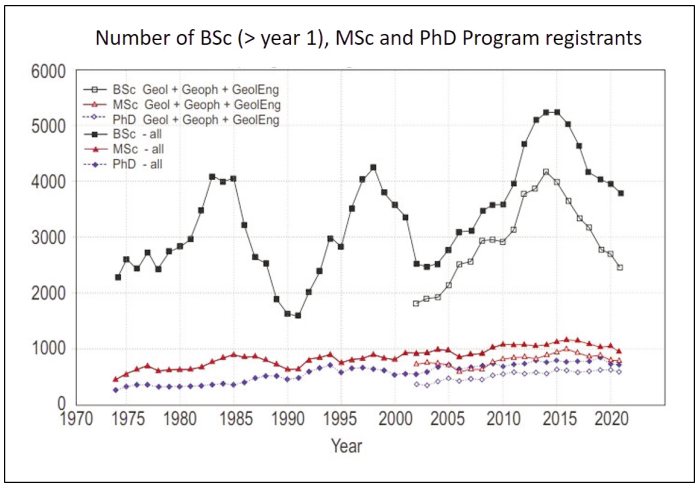

Figure 5. The number of geoscience students in Canadian universities from 1974 to 2021 (courtesy of the Council of Chairs of Canadian Earth Science Departments; cccesd.acadiau.ca/). The solid symbols include all students in their respective programs (BSc, MSc and PhD), the hollow symbols include the students in geology + geophysics + geological engineering fields minus the environmental sciences students. This separation was started in 2002. Note that there has been a drop of 1700 (42%) in 2021 from 4200 undergraduate geoscience students in 2014.

Attracting the Next Generation into Earth Sciences

Significant concern was expressed at the panel discussion regarding the lack of students enrolled in current post-secondary Earth science programs, especially in Canada. This is going to cause problems in the not-so-distant future as it will lead to workforce challenges that will inhibit tackling climate-change issues. This does not only represent shortages of geologists, but also a lack of Earth scientists with data processing expertise and knowledge of environmental issues. At the same time, qualified geoscientists are required to support mineral exploration and the petroleum industry, especially as these industries also contribute to the development of solutions to tackle climate change such as carbon sequestration and storage as well as critical mineral resource identification and extraction.

According to panelists and audience members, many Canadian, Australian, and European Earth science departments report decreased enrollment (e.g. see Fig. 5 for Canadian data) as the new generation looks to environmental science and geography to tackle climate change while viewing geology only in terms of mineral and petroleum exploration. This makes attracting and retaining students in geoscience programs difficult. The University of Toronto was put forward as an example of a successful Canadian post-secondary institution which has not seen a decline in geoscience enrollment. Their geology program is designed to connect to more popular, related fields such as environmental science, and employs an Earth-system science approach. This multi-faceted strategy has attracted a wider range of students, and helped to keep the geoscience program numbers steady, and may provide a template for other universities to follow.

Having good, engaging instructors in first-year geology courses may also help to attract students from other disciplines. Another useful approach may be to get children interested in the Earth sciences well before post-secondary educa-

tion, preferably before Grade 5 when many children have already developed math and science anxieties (e.g. Friesen 2009). Both initiatives may help bolster future enrollments. Encouraging further discussions regarding geoscience enrollment is necessary for the development and implementation of strategies aimed at increasing student participation in Earth sciences.

Relevancy and Communication with the General Public Through Education and Outreach

A lack of capacity is partly caused by the challenge of making Earth sciences more relevant to students and to society in general. Geologists understand the importance of what we do, but how do we effectively communicate that to students or people lacking an Earth science background, so they understand and support the geosciences? Other organizations, such as IGCP, are working on this issue. The IGCP's focus on geoscience education and its strategic position in UNESCO are assets that should be capitalized on. It is, however, limited by funding challenges. Half of the current IGCP projects involve social connections to local communities and all projects require an outreach component.

It was expressed during the panel discussion that Earth science projects would benefit from increased engagement with the public and Indigenous communities. Promoting and facilitating citizen science are effective ways of involving local communities. UNESCO Global Geoparks are important for demonstrating the applications of geosciences to the public. Ongoing funding for the IGCP Geoparks program, and the creation and maintenance of these parks, are important for facilitating interactions with and communications between scientists and society, while preserving these unique geoheritage sites. Furthermore, panels, committees, commissions, task forces etc., should strive for increased representation, the inclusion of early career researchers, and the involvement of non-geologists such as social scientists and geographers. Museums are key in communicating science with the public and attracting children into the sciences, yet museums also face financial struggles, especially at the provincial level in Canada.

Future Direction of the Earth Sciences

Geoscientists know that "*the present is the key to the past*" but John Ludden asked if, given the current climate emergency, Earth sciences should focus solely on the present and abandon 'deep time' to work towards solutions for imminent issues. The panel and audience members discussed this question at length and the consensus was that there is still value to be gained from the deep past, particularly with respect to mass extinction events and climatic variations. There is a need to better understand mass extinctions, what causes them, how to define and recognize them, their repercussions for life on Earth, and how the Earth recovered from past mass extinctions. Studying the deep time record of climate change may help us to better determine the long-term effect our species is having on the planet and give insights into the reality we are facing (the rates, causes, tipping points, etc., that relate to climate change).

Internal and External Geoscience Communication

The challenges facing the scientific community, specifically the Earth sciences, will require us to strengthen the ties between our various disciplines, and also with other sciences and the various fields of engineering. We are all in this together and only through working together can we develop meaningful strategies and solutions to tackle pressing issues. Specifically, Earth scientists need to cooperate with other disciplines including industry, engineering, biology, geography, and socioeconomics. Goals should include improving communications, timely sharing of data and research, and involving these other disciplines in Earth science organizations, panels, and committees. It was mentioned that Canadian geoscientists need to support and collaborate more with students and researchers from under-represented, under-funded countries on targeted, meaningful projects for the benefit of everyone. Broader volunteer-based participation by Canadians in IUGS, IGCP and other international endeavours will be crucial in the coming decades to stay connected, build synergies, and integrate between various disciplines, genders, and cultural diversities.

Funding

Funding is always a major concern to any researcher, and challenges associated with a lack of funding were a common theme during the panel discussion. As scientists, we have ideas for future projects and collaborations, but funding these undertakings is a challenge. A lack of consistent funding also exacerbates the issue of attracting the next generation of geoscientists; students will not come without funding. It would be ideal if a program (national, international, or a combination of both) with ample funding was created that supported academics and government researchers to pursue the recommendations outlined in the Hutton Series. Such a program would fund student projects on climate change, attracting candidates into the program. The question still remains though: where does this money come from? Geoscience research and solutions are expensive so there is a need to find ways to make these programs more affordable and prioritization will require rigorous cost-benefit analyses. This will attract people to the geosciences, contribute to effective societal change, and increase the relevancy of the Earth sciences. Funding is a complex, ongoing problem and requires the involvement and support of science agencies such as the Natural Sciences and Engineering Research Council of Canada (NSERC). NSERC has identified to "*mobilize knowledge on a global scale*" through support for the development of international partnerships as a priority in its strategic plan (NSERC 2022).

UNESCO World Heritage and Global Geoparks Discussion Panel

Following the presentations on UNESCO World Heritage Sites and Global Geoparks during the second day of the symposium, a panel examined areas that are under-represented in Canada and challenges experienced when developing geoparks in the Canadian context. It was apparent from the discussions

that Indigenous leadership, traditional knowledge, culture, and representation should be a requirement for future geoparks. The pros and cons of placing a global geopark in environmentally fragile areas, such as Canada's North, were also discussed. The potential negative impacts of increased traffic to these regions must be considered for aspiring geoparks. However, a geopark in the North would illustrate the impact of climate change (e.g. glacial retreat, the impacts of thawing permafrost on coastlines and infrastructures, etc.) while providing financial gains to northern communities through geotourism, and significant local employment opportunities. It was also pointed out that social scientists, especially geographers, and geoscientists would both benefit from improved collaboration and communication, especially with respect to identifying, developing, and maintaining UNESCO World Heritage Sites and Global Geoparks.

CLIFFS OF FUNDY GEOPARK FIELD TRIP

A three-day, post-conference field trip to the Cliffs of Fundy UNESCO Global Geopark (Nova Scotia), showcased this unique area. This geopark strives to support and promote the concept of "Two-Eyed Seeing" wherein Indigenous heritage and modern science are given equal consideration and respect. The field trip highlighted how the landscapes and seascapes of the region evolved, and how these features influenced the cultural, industrial, and agricultural heritage of the area. The field trip also provided insights into the process of establishing an UNESCO Global Geopark and touched on related topics including geoscience communication, UNESCO educational objectives, sustainable development with respect to mineral and energy resources, and geohazards associated with climate change and rising sea levels. The three intertwined pillars that form the identity of the Cliffs of Fundy Geopark (Mi'kmaw culture, highest tides, and sea cliffs) were explored in various stops throughout the park.

The Cliffs of Fundy Geopark is located within the territory of Kluskap (or Glooscap; Calder and Gloade 2016; Grant et al. 2022), named for the first human in Mi'kmaq lore (as detailed by the *Guide to 30 Geosites*). Highway 2 through the park is locally called the Glooscap Trail and the iconic painting of the Three Sisters (distinctive sea stacks along the Bay of Fundy coastline) by Gerald Gloade, a Mi'kmaw artist and current Program Development Officer for the Mi'kmawey Debert Project in Truro, greets visitors on a highway sign enroute to the Cliffs of Fundy Geopark, Nova Scotia (Fig. 2D). The Three Sisters figure prominently in the Glooscap legend where they played a trick on Glooscap when he was hunting moose. Glooscap punished the sisters by turning them into stone: the three prominent sea stacks located offshore (Calder 2017).

A key aspect of global geoparks is their cultural significance and involvement of local Indigenous communities. During the early stages in the process of designating the Cliffs of Fundy Geopark, community consultations with the Mi'kmaq Elders Advisory Council were held. Feedback from the Mi'kmaq community resulted in extending the eastern boundary of the park to include Mi'kmawey Debert (Calder 2018), which is a significant Indigenous archeological site that dates back 11,000 years to a time when the last continental glaciers were retreating (Cliffs of Fundy Geopark Society 2020). Other Mi'kmaq cultural highlights in the Cliffs of Fundy Geopark include sites of copper mining and weir fishing. The Mi'kmaq in the region mined copper locally which was widely traded across eastern North America centuries before it was 'discovered' by Samuel de Champlain (Hanley et al. 2022). Weir fishing, using inward water flow during high tides to direct the fish into the trap that are collected later during low tides, was a technique used by the Mi'kmaq for thousands of years (Bernard et al. 2015) and one weir is still used near Partridge Island.

The highest tides on Earth occur in the Bay of Fundy due to the shape of the bay combined with the resonance of 13.3 hours along the Gulf of Maine–Bay of Fundy system, which is similar to the period of the main tides in the open Atlantic Ocean (Piper and Pe-Piper 2022). Nearly as much water as the combined discharge of all the rivers of the world (Dai and Trenberth 2002) pours through the Minas Passage at average current speeds of 12 km/hour at a million m^3/sec (Karsten et al. 2008) twice daily with every tide. Modelling estimates that an array of turbines through the Minas Passage could generate 2000 megawatts, enough to power two million homes (Karsten et al. 2011); however the strong currents and suspended sediment continue to damage infrastructure (Piper and Pe-Piper 2022). Tidal bores moving upstream may also be visible. The tide schedule is important to consider when planning a visit along the Bay of Fundy, including to the Cliffs of Fundy Geopark.

The Cliffs of Fundy Geopark is defined by spectacular sea cliffs that were sculpted by the tides. These cliffs record evidence for the assembly and separation of the supercontinent Pangea. The cliffs are composed of rocks that include Paleozoic metasedimentary rocks, Triassic magmatic rocks that formed during the breakup of Pangea and the initiation of the Atlantic Ocean, and Mesozoic shales that contain evidence of the Triassic–Jurassic mass extinction event. Zeolites are abundant in the cliffs and include stilbite (the provincial mineral of Nova Scotia; Fig. 2H), mesolite, analcime and natrolite, with rare heulandite, laumontite, chabazite and thomsonite (Pe-Piper and Miller 2002). Flint, copper, basalt, and hematite were collected and used by the Mi'kmaq for tools, jewelry, and ceremonial purposes (Mi'kmawey Debert Cultural Centre 2014).

CONCLUSION

The authors hope that the symposium held in Halifax and the ensuing connections made between people, ideas, strategies, initiatives, and projects summarized in this paper will form a modest seed from which a new generation of Canadian geoscience diplomacy for the world will emerge and grow into more potent global geoscience solutions. Canadian geoscientists have contributed significantly to IUGS, to numerous IGCP programs, and to initiatives that link geological survey organizations across the world. Nevertheless, more collaboration is needed to address the enormous challenges, notably climate change, that are now facing humanity. While geoscientists recognize the important contributions that our discipline can

contribute to the global green transition, panel discussions during the symposium emphasized that improved education-outreach-communication programs are critical for conveying these contributions to the general public. Geoparks, such as the Cliffs of Fundy, combined with museums, are powerful communication platforms for engaging society, including children and their families, and inspiring the geoscientists of the future.

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