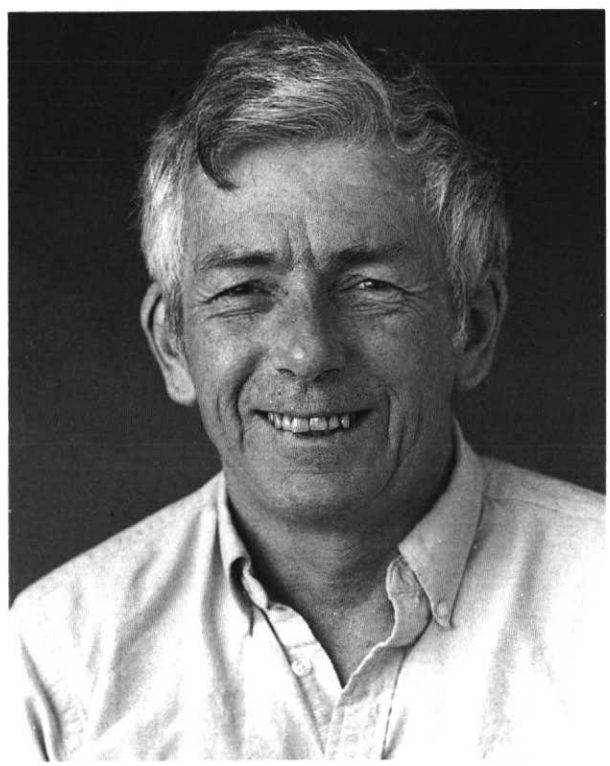
Michael J. Keen

F.R.S.C., Ph.D., F.G.A.C.
1935–1991

An Appreciation

Mike Keen, former President of the Geological Association of Canada (1974-75) and Logan Medallist (1986), died of a heart attack on 8 January 1991.



January 8th was bitterly cold in Halifax with the mercury dipping to –20°C during the night. Nevertheless, Mike decided to go out jogging as he had done regularly for the previous year-and-a-half. Returning home, he collapsed on the floor. Twenty minutes later, he was pronounced dead in the Victoria General Hospital.

Mike was born on 1 January 1935 in Seaford, Sussex, the elder son of John and Susanah Keen. The family moved to London just in time to experience the worst of the Blitz, with the two boys sleeping under the shelter of a steel table. After the war, Susanah Keen had to teach school to supplement the income of her husband, who worked as a commercial traveller until he could devote himself to theological studies, leading to ordination in the Anglican Church.

The family was not well-off and young Mike realized early that whatever he wanted he would have to get himself. The pocket money for his stamp collecting hobby came from a newspaper route. What would most enable him to get ahead, however, was his extraordinary ability to concentrate on his school studies and retain whatever he learned. Passing the eleven-plus exam with distinction, he won a scholarship to one of the famous London Guilds Schools (Haberdashers' Aske's Company in Cricklewood) where he again distinguished himself. While at school, he also became a dedicated scout, particularly enjoying mountain climbing expeditions in Wales. This experience qualified him to join the British Schools Expedition (BSE) to Iceland in 1951 as its youngest member. The expedition introduced him to scientific exploration and to the study of the environment, and had a major influence on his future choice of a career.

He went up to Oxford (University College) in 1953 on a State Scholarship to study science. His first choice was forestry, but the instruction proved unexciting. In the next term, he switched to general science (with emphasis on chemistry), before settling on geology. At University, he was an active participant in sports, competing in swimming and rugby. He also became a cox'n of his College's first boat.

While he enjoyed the challenge of university studies, the most enjoyable part of life was the summer holidays when he followed his prescription for a perfect summer: one month of reading for the sheer joy of it, and one month of summer work (in an ice cream factory) to earn enough to pay for a month of mountain climbing in Switzerland.

In 1957, Mike went to Cambridge (Trinity Hall College) to do graduate work at the Department of Geodesy and Geophysics located at Madingley Rise, the beautiful former home of Sir Gerard Lenox-Conyngham, the first Head of the Department. It was not a large department: about a dozen graduate students and half that many staff. The main lines of research were paleomagnetism, geochronology and marine geophysics.

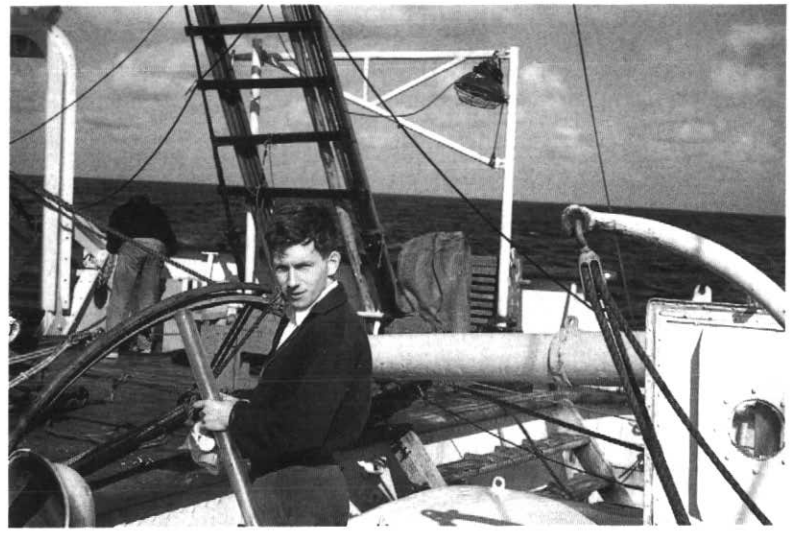
At first, it seemed unusual that this group of landlocked academics would be concerned with the structure and origin of the ocean basins. The origin of that interest dates from the pre-war years, when E.C. Bullard carried out the first seismic refraction experiments at sea (contemporaneously with Maurice Ewing in the United States), and B.C. Browne measured gravity at sea using submarines and equipment borrowed from Vening-Meinesz. During the Second World War, most Cambridge geophysicists worked for the Royal Naval Scientific Research and it was natural to use some of the results of that research in the postwar years when rebuilding civilian science.

By the time Mike reached Madingley Rise, the Department was the only significant research centre in marine geophysics outside the United States. Bullard, Browne and M.N. Hill led a group of young investigators who were expanding the frontiers of earth science, eventually to establish the foundations of plate tectonics.

The research tools included free-floating sono-buoys for single-ship seismic refraction experiments, a proton precession magnetometer, access to a high-precision echo sounder (developed by Tom Tucker and Tony Laughton at the National Institute of Oceanography in Wormley, England), and equipment for deep-sea coring and dredging. The marine research was possible because of the access to *RRS DISCOVERY II*, built for Antarctic whaling research in 1929. *RRS DISCOVERY II* was old

and not very large, but, by the standards of the day, beautifully outfitted and rather comfortable. Most of the research students who sailed on her remained devoted to oceanic research for the remainder of their careers.

Mike sailed on *RRS DISCOVERY II* twice, in 1958 and 1960, collecting deep-sea cores to study the physical properties of sediments. Maurice Hill had collected hundreds of miles of profiles of total magnetic field measurements showing unexplained anomalies. In the search for a cause of the anomalies, Mike was to look at the physical properties of sediments while Drummond Matthews looked at the properties of basalts dredged from the sea floor. Mike pioneered the measurements of paleomagnetic properties of sediments, but failed to detect any reversals because the cores were not long enough.



Mike's Cambridge research (1960, 1963a) did not produce any breakthroughs. The main benefit of being a part of the team was that everybody participated in the projects of other researchers, and at sea, all the duties were shared. With that kind of training, he was well prepared to lead a research team of his own and he looked for fresh fields to conquer.

Word was received in Cambridge late in 1960 that Canada was embarking on a major expansion of oceanography. Two Institutes of Oceanography (at Dalhousie and UBC) were formally established in 1958, a new federal research laboratory was being built on the shores of Bedford Basin and, most importantly, a new ship was to be constructed. Almost 100 m long and more than 4500 t displacement, *CSS HUDSON* was to be the most advanced research platform in the world, with funds provided to equip it with the latest equipment and instrumentation. The opportunity to be a part of a new scientific thrust was irresistible, and when Maurice Hill received a letter from Ronald Hayes, Director of the Institute of Oceanography at Dalhousie (IODAL), asking about research students who might be interested in joining his Institute, Mike jumped at that opportunity. In his first letter to Hayes, dated 23 March 1961, he staked his ground and stated:

> "... To start useful work I know I should like a ship, a deep-sea winch, a P.D.R., a corer and a dredge. This would lead to a geological programme. Studies of the structure of the sea-floor would require ... a magnetometer ... [to] be followed by other geophysical techniques such as gravimetry and seismic prospecting."

Hayes was obviously impressed and on May 8 wrote to Mike:

> "... we should like very much to have you join us here at Dalhousie as Assistant Professor of Geology and Associate of the Institute of Oceanography. The salary offered is $6500 annually... We have already discussed in correspondence the duties involved in this position, which are to develop teaching and research in Oceanography..."

Mike left Cambridge for Canada on 27 July, but did not go directly to Halifax. Instead, he flew to Toronto and then continued west to spend several weeks climbing in the Rockies. Eventually he reached Halifax, refreshed and ready to start his enormously successful career in Canadian science.

His appointment was in the Department of Geology, where he was expected to take part in undergraduate teaching. He decided that he should teach marine geophysics, a subject of no interest to his own department. He arranged a cross-appointment in the physics department where Ewart Blanchard was carrying out land geophysical investigations. Immediately, they proceeded to organize the first Canadian marine geophysical expedition on board *HMCAV SACKVILLE*. The object of the expedition was to measure crustal thickness off Nova Scotia using depth charges fired at sea, and recording shots at three locations along the coast. In carrying out this experiment, Mike exhibited the personal traits which would characterize all his endeavours in years to come: initiative to mobilize a team and supervise the around-the-clock work, energy to battle bureaucratic forces, ingenuity in solving unforeseen problems, scientific acumen to select a significant problem, and a willingness to leap into the unknown by starting a research project which was outside his immediate past experience and training.

The project was so successful that over the next six or seven years, the team of Keen, Blanchard and a succession of research students continued to map the deep structure of the Earth's crust around Atlantic Canada, producing the first description of the roots of the Appalachian orogen in eastern Canada (1964, 1965, 1966, 1968a).

In 1963, Mike Keen married Charlotte Davidson and thus started a remarkable scientific co-operation which lasted until the end. Almost half of the original scientific contributions in his bibliography are co-authored by M.J. and C.E. Keen. The joint papers range from "The size analysis of turbidity current sediments" (1963b) to a synthesis of our knowledge of the continental margins in eastern Canada (1974), and the first description of the deep seismic reflection profiles acquired across the northern Appalachians (with others, 1986).

The marital union was less successful on a personal level and, by mutual agreement, Mike and Charlotte separated in 1972. Three years later, at the GAC Annual Meeting, Mike met Susan Atkinson, a structural geologist; two years later they were married. With their three children, Alison, Rebecca and Jonathan, they formed a warm and tight family circle that gave Mike enormous personal contentment. The progress and development of the children totally absorbed the personal side of his life.

Mike was happy, productive and successful at Dalhousie, becoming a Professor and Head of the Department of Geology (in 1969) and serving as Assistant Dean of Arts and Science (1973-1975). A direct and fluent writer, he made a major contribution to marine geoscience education with his book *An Introduction to Marine Geology* (1968b). In addition to continuing his own research with his students, he pursued a wider vision of his role at the university. He believed that Nova Scotians should be able to get as good an education at home as anywhere else, and therefore proceeded to build successful research teams which acquired international stature. In particular, he supported the drilling of the ocean crust (Deep Sea Drilling Project leg 37, Azores, Bermuda and Iceland) and worked hard to provide funds to equip his department with the best geochemical analytical facilities available. With its enhanced reputation, the Geology Department was able to attract first-rate staff, and doctoral and post-doctoral students, thus becoming one of the leading Canadian centres for Earth Science studies.

He was loyal to the staff of the department, supporting their projects, suggesting new and promising directions and initiatives to be pursued, and seeking funding and other forms of outside support. Above all, he was interested in promoting the careers of students, constantly challenging them to excel and to exceed his expectations. While this was a source of tremendous satisfaction when his protégés did well, it was also a cause of frustration and disappointment if the students did not quite measure up to his standards. The best were frequently nominated for awards which he considered a means of encouraging scientists, particularly early in their careers, to exert greater effort and to strengthen their commitment to science.

In order to promote earth sciences in Canada, Mike took an active interest in the work of many professional organizations. His dedication, hard work and many initiatives usually led to the top. In addition to being President of the GAC (1974-75), he was also President of the Canadian Geophysical Union (1981-83), the Canadian Geological Foundation (1979-83), the Atlantic Geoscience Society (1973-74), and Chairman of the Canadian Geoscience Council (1984-86). His contribution to Canadian science and the range of his influence were recognized in 1974 when he was elected Fellow of the Royal Society of Canada.

In 1977, Michael Keen joined the Geological Survey of Canada as the second Director of the Atlantic Geoscience Centre (AGC). The Centre, the east coast division of the GSC, was formed in 1972 out of the geology and geophysics sections of the Bedford Institute of Oceanography and the Eastern Petroleum Group, transferred from Ottawa to Dartmouth.

The attraction of the GSC appointment was that it provided a larger stage on which to pursue his vision: linking science (and earth science in particular) to national issues. The adoption of the Law of the Sea Convention, with its "geological" definition of the outer limits of the economic zone, provided an opening which Mike fully utilized. He worked hard and successfully to demonstrate to the Federal Government that ocean mapping had become an essential tool for the protection of national sovereignty. This led to close co-operation with the Department of External Affairs in the Georges Bank boundary dispute and the preparation of a synthesis of the geology of the disputed area (by H.B.S. Cooke) which became a part of the Canadian submission to the World Court in the Hague. Similar co-operation developed over the boundary dispute with France.

Pursuing the linkage between earth science and national issues, he was able to assist W.W. Hutchison in securing major new funding for the Frontier Geoscience Programme (FGP). At AGC, the significant portion of the funds was used to contract deep seismic profiling, an enormously successful project led by Charlotte Keen, which has revolutionized regional and thematic understanding of the tectonics of the Appalachians and continental margins.

As a part of his broader vision, he and Hutchison were able to secure Canadian participation in the Ocean Drilling Programme (ODP). His rationale was that "Canadian science is too inward looking, too parochial. ODP will make Canadians work internationally and be exposed to international ideas." His hopes were justified by the large number of Canadians who have participated in various phases of ODP and who have contributed to the resulting publications.

The peak of his influence came in 1985, when he was made a Deputy Team Leader of the Study Team on Natural Resources of the Ministerial Task Force on Program Review (Nielsen Task Force). With characteristic enthusiasm and energy, he made a considerable impact on the work of the study team, though he was later disappointed by the lack of follow-up.

Given the opportunity, Mike might have preferred to extend the range of his influence by becoming a senior government or university administrator. However, his temperament and personality were not suited for those tasks. He was a doer who could clearly see the end results and was impatient to get there. He did not allow that others might have different agendas and was not willing to spend time and effort to understand why others might have opposed his initiative.

After eleven years as the Director of AGC, Mike decided to return to his first love and pursue research as a senior scientist within the GSC. At first, he looked for a research topic within the general concern for global change. He loved the outdoors and had a deep concern for the environment, but the research within the field was not quantitative enough to appeal to his talents. Instead, he followed a hunch that the chemistry of basalts from older oceanic crust may correlate with the water depth at the time of their eruption on the sea floor (1990a). A second paper on this topic was submitted to *Nature* only a few weeks before his death.

Mike Keen was a passionate and committed human being. He devoted his enormous energy and considerable talent to the causes that he embraced. Foremost among these was his devotion to his family and loyalty to friends and institutions which he served.

After his family came his passion for science. It was a characteristic of his approach to research that 40 out of some 70 papers in his bibliography have joint authorship. He was a builder of teams, always on the lookout for a new problem. He had a superb high school and undergraduate education and a mind to retain most of it for the rest of his life. With that background, he could make leaps of faith and see connections in a scientific problem long before his colleagues wrote down the first equation. He was stimulating company, had the scientific common sense to sniff out the problems which could produce significant results, and had a solid scientific background to sketch out for others the approach toward the solution.

There were three recurring themes in his scientific career. The first was the structure and evolution of the continental margins. He pursued this interest starting with the early refraction work, through various papers synthesizing the accumulating knowledge, to the publication of the DNAG volume on Continental Margins (1990b) which he co-edited with Graham Williams. The science in the DNAG volume largely resulted from the way that he led and inspired AGC. The volume is his fitting memorial.

The second theme was his interest in the ocean crust and in ridge processes, particularly through his support of ODP. In the early part of his career, the knowledge of the deep-sea crustal geology was based on indirect geophysical observations. Through his support of the work of Aumento and Hall at Dalhousie, he was instrumental in securing geological samples as direct evidence. The origin and composition of ocean basalts were problems which occupied him until his last day.

The third theme was science and society and he pursued it at all levels, from debating and promoting science in national forums to working to bring science to local schools. His particular concern was to give women an equal opportunity to participate in science. He gave them encouragement and unflagging support, and rejoiced in their success. He published a number of articles in *Geoscience Canada*, ranging from "Earth science departments in the eighties: prepare for the worst, you may be surprised" (1979) to "Children should learn to appreciate Science, Mathematics and Technology in school" (1988). These were polemical articles, designed to prod, stimulate discussion and, if possible, lead to action. They were an expression of Mike Keen's deep concern for the lack of appreciation of science by the general public. He felt instinctively that communication of scientific accomplishments to the public is not only an exciting and rewarding task, but also a prerequisite for maintaining public support for the funding of scientific research (1990c).

His last passion was the outdoors, especially the challenge of dangerous sports. Mountain climbing was an early love, pitting his own skills and nerves against a rock face. In his early years at Dalhousie, he took up sailing and skiing, working at perfecting his skills in the latter by always attempting a more challenging slope. In his final years, he approached white water canoeing with the vengeance of one thirty years younger. He was not just going to enjoy the scenery while paddling down some quiet stream. Instead, he worked at honing his skills until he obtained Canoe Nova Scotia Lake Water Level III certificate and was in the process of acquiring Red Cross Life Saving and CPR certificates so that he could qualify as an instructor.

All who knew Mike agree that he possessed a tremendous drive, great ambition, and energy to pursue greater influence. Where does such an uncommon determination to pursue distant goals come from? Why can one individual look ahead so much farther than the rest, and then have the courage to reach beyond his grasp?

It is not easy to answer these questions, nor would it be fair to offer explanations or judgements at this time. Mike was born with a receptive mind which propelled him through excellent English schools to Oxford and Cambridge. He acquired knowledge which he used skillfully to drive himself toward some distant goal. He was determined to make a difference and, as the years went by and he assumed greater responsibilities, he was able to extend his influence over an ever-widening stage.

If our understanding of Mike's goals is correct, then his life was an outstanding success. He encouraged, challenged and pushed all who came in contact with him. Mike Keen was a person who made a difference in people's lives, who looked for the best in others, and gave the best he had.

BOSCO D. LONCAREVIC

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Editorial Note: The following articles highlight recent advances in oceanography, with special emphasis on geological studies. They illustrate the science that Mike Keen embraced and pursued, and were prepared for *Geoscience Canada* by Mike's colleagues in memory of his friendship and leadership.