Journal of Glaciology, Vol. 34, No. 116, 1988

OBITUARIES

JOHN H. MERCER
1922–1987

GLACIOLOGY lost one of its most perceptive thinkers with the passing of John Mercer on 3 July 1987 in Columbus, Ohio, U.S.A. John was born in Cheltenham, England, on 29 October 1922, the third child of Harriet and John W. Mercer. He is survived by his two sisters, Mary and Elisabeth, his wife, Mary Fink Mercer, who he married in 1965, and their daughter Jane, who was born in October 1971. John was educated at private schools in Cheltenham and, later, at Gordonstoun in Scotland. During World War II he served in the British Merchant Marine (1940–46) as a radio man. Following the war, he entered the University of Cambridge, where he received a B.A. degree in geography in 1949. It was during his undergraduate days that John came under the influence of W. Vaughan Lewis, whom he very much admired both for his enthusiasm and the glaciological research he was doing. Perhaps it was this that guided his later career. He then moved to Canada, where he received his Ph.D. in geography from McGill University in 1954. John was a Research Scholar from 1954 to 1956 at the Australian National University in Canberra, where he studied land use and population in western Samoa. He returned to Canada and worked in the Canadian Hydrographic Office in Ottawa as a geographer in 1957 and 1958. During 1959–60, 1961–62, 1964, and 1966, the American Geographical Society employed him at its World Data Center A for Glaciology in New York.

The turning point in John's career, at least for glaciologists, was in 1960, when he became a Research Associate at The Ohio State University, in the Institute of Polar Studies (recently renamed the Byrd Polar Research Center, following an endowment by the family of the Antarctic explorer, Admiral Richard E. Byrd). He remained at The Ohio State University until his death, becoming its first Senior Research Scientist. Although John had studied glacial geology as early as 1952–53 on Baffin Island, he used his new position to launch field studies of glacial geology in Alaska's Prince William Sound in 1967, in western Greenland in 1968, in the Reedy Glacier (1964–65) and Beardmore Glacier (1969–70) areas of the Transantarctic Mountains, Antarctica, and most important of all, in South America, especially Patagonia, every year from 1967 to 1987, except 1968 and 1984.

John's seminal paper in glaciology, "Antarctic ice and Sangamon sea level", published by IASH in 1968, presented glacial geological evidence that the West Antarctic ice sheet was larger in the past than it is at present, based on moraines along outlet glaciers through the Transantarctic Mountains, and smaller, based on inferences from high-altitude glacial and lacustrine deposits. Following the suggestion by John Hollin in 1962, that climatic warming and rising sea-level cause Antarctic ice shelves to retreat, Mercer postulated that the West Antarctic ice sheet, being grounded well below sea-level and terminating in floating ice shelves, was vulnerable to these changes and may have collapsed altogether during the last interglacial when Antarctica may have been warmer and sea-level may have been higher. In 1978, in *Nature*, he pointed out that "green-house" warming from burning fossil fuel could have the same effect during the present interglacial. Outlet glaciers, a class of ice streams, are especially sensitive indicators of these changes. Major theoretical and field studies of Antarctic ice streams, especially in the Transantarctic Mountains and in West Antarctica, can be traced directly to these ideas by John Mercer.

The first major glaciological field study of an ice stream through the Transantarctic Mountains and feeding the Ross Ice Shelf, like Reedy and Beardmore Glaciers visited by Mercer, was in 1978–79, when the University of Maine began a comprehensive photogrammetric study of Byrd Glacier. That was also when the British Antarctic Survey conducted the first field studies of Rutford Ice Stream, which drains West Antarctic ice into the Ronne Ice Shelf. In 1981, the University of Maine initiated a photogrammetric study of Pine Island Glacier and Thwaites Glacier, which drain about one-third of the West Antarctic ice sheet and calve into the Pine Island Bay polynya. This was followed by field work in 1984–85. By far the most ambitious study of West Antarctic ice streams in this decade, however, has been the Siple Coast Program of the U.S. National Science Foundation. It has funded glaciologists, primarily from the University of Wisconsin, The Ohio State University, and NASA's Goddard Space Flight Center, to study the dynamics and mass balance of all West Antarctic ice streams supplying the Ross Ice Shelf. Preliminary results were presented by the A.G.U. at the "Chapman Conference on Fast Glacier Flow" in 1986, the lead papers being given by Bentley, Shabtaie and others, Whillans and Bolzan, Bindschadler and others, and Blankenship and others.

Mercer's ideas about the inherent instability of the West Antarctic ice sheet led to numerous numerical simulations, notably the formation of the ice sheet at the University of Chicago, disintegration of the ice sheet at the University of Maine, and the surging potential of its major ice streams at the University of Colorado. A book, *Dynamics of the West Antarctic ice sheet*, edited by C.J. van der Veen and J. Oerlemans, was devoted to West Antarctic ice-sheet stability. Mercer was also invited to speak on this subject at national and international conferences too numerous to list here.

One year after his 1968 West Antarctic ice-sheet paper, Mercer proposed ice shelves at the last glacial maximum covering the Arctic Ocean and northern Norwegian Sea, and connected with a marine ice sheet on the floor of the Barents Sea, as Schytt and others had just proposed on the basis of raised beaches. Mercer attributed the Younger Dryas cooling in Europe to disintegration of this ice shelf and latent heat removed from the atmosphere in order to melt the resulting icebergs, as ocean currents transported them southward along the Atlantic coast of western Europe. This was the first suggestion that huge floating ice shelves could also exist in the Arctic and that their dynamics could play a crucial role in Northern Hemisphere climatic history during the last deglaciation. In 1970, Mercer coined the term "marine ice sheets" to describe ice sheets grounded well below sea-level on polar continental shelves, such as in West Antarctica today and in the Barents Sea at the last glacial maximum. He then postulated that marine ice sheets typically co-exist with floating ice shelves, and he went on to propose that an Arctic ice sheet consisting of ice grounded on polar continental shelves and ocean ridges, and ice shelves floating over the deep ocean basins between, may have existed during Northern Hemisphere glacial maxima, much as the Antarctic ice sheet exists today. This thread was taken up at the University of Maine in the Northern Hemisphere ice-sheet reconstructions for CLIMAP, as published in *The last great ice sheets*, edited by George Denton and myself. It has led to exciting new research on Arctic and sub-Arctic continental shelves, embayments, and seas in Canada, Scandinavia, and the U.S.S.R., notably by D.A. Hodgson, Jean-Serge Vincent, Lester King, Gordon Fader, Tore Vorren, Otto Salvigsen, Yngve Kristoffersen, Anders Elverhøi, Anders Solheim, and, most indefatigable of all, Mikhail Grosswald and colleagues at the Institute of Geography in Moscow. A new book, *Interaction between glaciation and the atmosphere and oceans*, published in 1987 by the Academy of Sciences of the U.S.S.R. and edited by Viktor Kotlyakov and Mikhail Grosswald of the Institute of Geography, for the first time gives a central role to marine ice sheets and their associated ice shelves in the dynamics of global climatic change. In particular, the book presents the Arctic during the last glacial maximum as almost entirely fringed by marine ice sheets; in Eurasia, occupying the continental shelf in the East Siberian, Laptev, Kara, and Barents Seas; these are connected by ice shelves to the marine ice sheet over the Queen Elizabeth Islands of Arctic Canada, with additional ice shelves in the Bering Sea, Sea of Okhotsk, and Sea of Japan.

Central to Mercer's ideas about the stability of marine ice sheets and their associated ice shelves was his belief, based on the absence of ice shelves along the western Antarctic Peninsula north of the 0°C summer isotherm, that temperate ice could not produce extensive ice shelves. His insight on this point was finally confirmed theoretically by Kees van der Veen in 1983, 19 years after Gordon Robin and Raymond Adie made the initial suggestion in 1964. This illustrates the fact that every scientific discovery has a history, and it is often almost impossible to be sure at which point a given idea became widely accepted and led to a major new direction in science.

The history of marine ice sheets as an idea is no exception. On the Scott expeditions, Edgeworth David noticed evidence on islands in the Ross Sea that grounded Antarctic ice once extended well north of the present-day calving front of the floating Ross Ice Shelf. That West Antarctic ice was grounded far below sea-level was discovered during the International Geophysical Year, 1957–58, and creating the marine ice sheet by grounding a floating ice shelf was first proposed by Harry Wexler in 1961. He computed thickening rates from surface snowfall and basal freezing. The first map of the marine ice sheet in West Antarctica was provided by Charles Bentley and Ned Ostenso, also in 1961, based on data from tractor-train traverses in 1957–60. Voronov, in 1960, was the first to link the extent of marine ice to changing sea-level. Weertman, in 1974, provided the first theoretical demonstration that a marine ice sheet and its fringing ice shelves may be inherently unstable.

The possibility of a marine ice sheet in the Arctic was first proposed by Sir William Thompson in 1888, and the first field studies demonstrating that such was the case in the Barents Sea were by Geard De Geer, who mapped the extensive distribution of striations on islands only 10 years later. Additional evidence was not reported until another seven decades had passed, when Valter Schytt, Gunnar Hoppe, Misha Grosswald, and Weston Blake published their map of raised beaches in the Barents Sea. Two years later, Blake published a similar map of dated raised beaches in the Queen Elizabeth Islands of Arctic Canada, and proposed the name, "Innuitian ice sheet", for the marine ice sheet that must have existed there at the last glacial maximum. Blake, therefore, was involved in discovering both of the former marine ice sheets in the Arctic. That these discoveries were not accepted easily is evident from the publications by Geoffrey Boulton and John England on the subject.

Important as all the other contributions to the developing knowledge of marine ice sheets are, the fact remains that John Mercer was the Adam who gave them a name, the first to point to their inherent instability, the first to emphasize their intimate association with the existence and dynamics of floating ice shelves, the first to give them a critical role in the glacial history of both the Arctic and the Antarctic, and the first to direct serious scientific attention to the only one in existence today, the West Antarctic ice sheet. These are reasons enough to honor John Mercer with the title "Father of Marine Ice Sheets".

There can be no hesitation with respect to John Mercer's other great contribution to glaciology. He stands alongside C.C. Caldenius as a pioneer "father of South American glacial history". For two decades, right up to and including the year he died, John Mercer devoted his major energy to studying the Quaternary Andean glaciations. These studies have much more than regional significance; they constitute the one great body of work on glaciation in the Southern Hemisphere. When his studies on the Quaternary glaciations in the Transantarctic Mountains are included, they provide a glacial history spanning 72° of latitude, from lat. 86°S. on Reedy Glacier to lat. 14°S. on the Quelccaya ice cap in Peru. Not even in the Northern Hemisphere, with its much more extensive landmasses, has one man made so extensive a study of glacial history. With his unique perspective on Southern Hemisphere glacial history, John was able to make major contributions to the ongoing synthesis of the global glacial history of the Quaternary, especially the history of the last deglaciation. Time and again, he exposed weaknesses in ideas by Northern Hemisphere climatologists and Quaternary geologists on how global glaciation cycles came about, and the mechanisms causing them.

Three of his glacial geological–climatological discoveries in the Southern Hemisphere are of particular global significance to glaciologists. His work on Reedy and Beardmore Glaciers in the Transantarctic Mountains provided two of these. First, he showed that these outlet glaciers did not change elevation at their East Antarctic end, but that their West Antarctic end had been much higher in the past and, for Reedy Glacier, much lower as well. He concluded that only advance and retreat of the Ross Ice Shelf grounding line could cause this and, by implication, major growth and collapse of the West Antarctic ice sheet that, forced by sea-level changes, had to wax and wane in lock-step with Northern Hemisphere ice sheets.

Secondly, along with George Denton and Wakefield Dort, Jr, Mercer noticed that local alpine glaciation in the Transantarctic Mountains was out-of-phase with advance and retreat of the West Antarctic ice sheet, and he attributed this to reduced precipitation in the mountains during full glaciations of the Pleistocene cycle. This reduction would also have prevented the East Antarctic ice sheet from participating significantly in the large-scale growth and shrinkage of the West Antarctic ice sheet that was caused by sea-level, hence explaining why high lateral moraines alongside Reedy and Beardmore Glaciers pinch out at their upper, East Antarctic, ends. With this observation, Mercer made perhaps the most important distinction between marine ice sheets, terrestrial ice sheets, and alpine glaciers; a distinction with global significance that helps to explain apparent anomalies in parts of the Northern Hemisphere record of glaciation.

Thirdly, a major new "discovery" heralded by some prominent ice-sheet modelers is that delayed isostatic sinking beneath the southern margins of Northern Hemisphere ice sheets causes the surface equilibrium line to retreat because of basal sinking just when it is also forced to retreat due to increased solar radiation in the Milankovitch cycle, and this reinforcement produces the irreversible retreat of ice margins that is associated with the terminations of glaciations in the oxygen-isotope stratigraphy of ocean-floor sediments. Mercer pointed out that alpine glaciers in the Southern Hemisphere, including the Andean glaciers he had studied, had essentially the same chronology of retreat as found in the oxygen-isotope record and along southern margins of Northern Hemisphere ice sheets, yet these alpine glaciers had no ongoing isostatic sinking to reinforce equilibrium-line retreat. There is more to terminations than Milankovitch forcing reinforced by subglacial isostatic sinking.

John Mercer taught me my first two important lessons as a scientist. First, nobody is "first" with a scientific discovery. With the exception of the thought that thermal convection may take place in many of the lower regions of the Antarctic ice sheet, an idea that has not gone anywhere, my "first" contribution to glaciology was the observation late in 1971 that much of the West Antarctic ice sheet had a concave surface profile, whereas equilibrium theory predicted a convex profile, and the concavity seemed to be associated with ice streams. Therefore, I concluded that the ice sheet was disintegrating and that the vehicle for disintegration was surge-like flow in the ice streams. I linked together a rather elaborate chain of speculations and circulated them privately in 1972 as *ISCAP Bulletin* No. 1, a call for a major study of West Antarctic ice streams. I was at The Ohio State University at the time, and one day John Mercer walked into my cubicle and handed me two reprints, in which he had postulated disintegration of the West Antarctic ice sheet based not on speculation but on his own field work done in 1964, 7 years earlier. Moreover, he was ahead of me by 120 000 years on when it happened – during the Sangamon interglacial.

My second lesson left me notably wiser, as had the first, but it also left me sadder. John had shown a spectacular slide of Fitz Roy during one of his lectures on the glacial history of Patagonia. I was determined to visit it, so on my return early in 1973 from Deception Island, where I had been studying the effects of a subglacial volcanic eruption, I walked into the British Club in Rio Gallegos, Argentina, plopped myself in a chair, put my boots up, and waited for John Mercer to show up. A day or two later he walked in with Walter Sander. He needed new tires for the jeep he had rented, and I offered to buy them if he would drop me off at Fitz Roy and pick me up 3 days later. I might mention that Walter had the distinction of appearing in that paragon of upper-class scientific respectability, the *National Geographic Magazine*. During World War II, a German submarine had dropped him and two other meteorologists on the east coast of Greenland to man a weather station. Capturing the station was the only military action by the U.S. Coast Guard during the war, and a *National Geographic Magazine* cameraman was on the scene. He photographed a horde of Coast Guardsman marching these three lonely Germans down to the beach at gunpoint, and it appeared as a full-page picture in the magazine with the caption "Coast Guard apprehends Hitler's henchman". John not only took me to Fitz Roy but, over a period of several days, he gave me a guided tour of the large area in southern Patagonia where he was studying glacial geology, from Condor Cliff to Moreno Glacier (whose ice-dammed lake had burst through the ice dam the previous year and sent a wall of water down Rio Santa Cruz, washing out many bridges and farms). He showed me how he recognized glacial deposits, where to find datable material and how to piece together a glacial history. He gave me an appreciation of glacial geology that I have never lost, and it impressed me so much that I made the glacial geological record primary input to the computer reconstructions of former ice sheets done for CLIMAP and published in *The last great ice sheets*. The lesson I learned, however, was the most important legacy a scientist can make to his profession is not the work he does himself but the students he trains and leaves behind to carry on. The sad part of that lesson was my realization that I was in the presence of one of the great teachers of our time, and he never held a departmental appointment where students could gather around his feet and learn from the master.

It is commonplace to acknowledge that, in every generation, scientists learn anew that their view seems so lofty not because of their stature, but because they stand on the shoulders of the giants who came before them. I wish to acknowledge that the view from the shoulders of John Mercer has been spectacular, and we will miss him sorely.

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