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Edited by G. de Q. Robin
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The climatic record in polar ice sheets

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A study of isotopic and temperature
profiles in polar ice sheets based on
a workshop held in the
Scott Polar Research Institute, Cambridge

Edited by
G. de Q. ROBIN

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PREFACE

Prior to 1973, the study of temperature profiles in polar ice sheets developed independently of the corresponding study of the isotopic profiles, although both were obtained from the same boreholes and both recorded aspects of past climate. A grant from the Royal Society enabled the editor of this volume to bring together an international group of experts to the Scott Polar Research Institute, Cambridge, in January 1973, and again in March 1973, for a workshop to integrate studies of isotopic and temperature profiles in polar ice sheets.

The following took part in the workshop: from 1–14 January 1973, the main participants were D. Jenssen (SPRI and Melbourne), S. J. Johnsen (København), C. Lorius (Grenoble), W. S. B. Paterson (Ottawa), G. de Q. Robin (SPRI; convenor). Others included N. J. Shackleton (Cambridge), C. Neal (SPRI), J. A. Campbell (SPRI and Melbourne; computing assistant). From 12–24 March, the main participants were W. F. Budd (Melbourne), D. Jenssen, S. J. Johnsen, C. Lorius, N. Reeh (København), G. de Q. Robin, J. Weertman (Northwestern University). Others included P. Gudmandsen (Technical University of Denmark), C. W. M. Swithinbank (British Antarctic Survey), C. Neal, J. A. Campbell, and G. S. Boulton (Norwich).

The purpose of the workshop was to study the relationship between isotopic δ values and temperature suggested by various authors such as Epstein and Mayeda (1953), Scholander *et al.* (1962) and Dansgaard (1964). If the isotopic record from an ice core provided a true record of past climate, this record of past surface temperature could be incorporated in a model of the flow of an ice sheet to calculate temperature–depth profiles. The results could then be compared with observed temperature–depth profiles, and with earlier calculations of Robin (1955), Zotikov (1961) and others that were based on the assumption that dimensions and flow of an ice sheet, as well as the climate, were in a steady state. An improved match could indicate that the isotopic–temperature relationship based on present-day observa-

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tions had also applied in the past. Although on physical grounds this would seem likely, confirmation that the isotopic–temperature relationship also applied in the past was necessary because so many processes affect the isotopic δ values of falling snow, and because of the obvious importance of the isotopic profiles as climatic records.

Interpretation of both isotopic and temperature profiles depends on the flow and past behaviour of ice sheets as well as other parameters. At the second workshop meeting, it was decided that the outcome of the study should be published as a monograph, and that this should cover not only the model calculations initiated at the workshop but also discuss the related data used in unravelling the past history of the ice sheet. A general plan for the monograph drawn up at that time has been followed with only limited modification. A list of contributors, including some glaciologists who had not taken part in the workshop, was tentatively agreed and the present editor accepted responsibility for the monograph.

Although progress with the monograph was slower than originally planned, due to delays in editing following earlier delays with model computations and some written contributions, there have been compensations. Our understanding of a number of topics covered in this monograph is now greater than in 1973. Most sections have been revised or reviewed to incorporate important advances and, if there are omissions in this respect, the responsibility lies with the editor. Other sections that were planned but not completed have been written by the editor to complete the coverage of the monograph. Use of symbols has been standardised throughout so that contributions by different authors are integrated into the monograph and are complementary to each other. Although some repetition may occur between different contributors, this has been kept to a minimum.

Chapter 5, which presents the main computations, models and conclusions from modelling, stands as an independent section, as well as providing the core of the monograph. While the modelling studies provide a considerable amount of material that may be of more interest to glaciologists than climatologists, the studies of temperature profiles at Byrd Station and Camp Century based on the input of ‘isotopic’ temperatures provide the main justification for the workshop.

For a full assessment of the conclusions one needs to appreciate the results of these modelling studies, as well as the reliability of measurements of individual parameters presented in chapter 3. The summaries of the basic techniques and parameters used in modelling, and the outline of the glacial geology of Greenland and Antarctica, may serve as an introduction to these subjects for those not familiar with this work. Similarly, the final chapter may be understood without mastering all the details of chapter 5. It draws on conclusions of the modelling studies, tests them against other series of data, and suggests a guide to the accuracy with which past climate may be deduced from isotopic profiles. Comparisons between isotopic profiles from different ice cores show that long-term climatic changes can be

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similar over wide regions of the Antarctic, but that isotopic ‘noise’ prevents effective comparison over short periods. The climatic record from ice cores and a global index of past climate is then discussed to show how polar climatic trends compare with world trends.

While this monograph brings together an overall picture of the activities initiated by the workshop in Cambridge, a number of individual studies stimulated by the workshop have been published elsewhere and are referred to at many points in the text. The workshop and subsequent developments have drawn on the help of many people to whom thanks are expressed. Guidance to the editor over the contents of individual chapters has been given by the editorial advisers. This guidance has taken a different form for each chapter and has been a great help. However, responsibility for the contributions in individual sections rests with the named authors, or with the editor where an author is not named.

Production of the monograph would not have been possible without the support of the Royal Society, primarily with travel grants and also with secretarial and other expenses. Cambridge University Press have given patient support and encouragement, while many members of the staff of the Scott Polar Research Institute have assisted in various ways. Thanks are especially due to Miss Elaine Lingham, who has helped first in a secretarial and then in an editorial capacity, from the inception of the monograph to its completion, and her confidence and interest in the project have been of great benefit throughout. Mrs Julie Jones, who provided the secretarial and other services for the workshop sessions, and who later became Director’s assistant, provided much help in earlier years. Mrs Alison Wood and Miss Margaret Thomson continued to shoulder the burden of typing and retyping succeeding versions of the manuscript with patience and accuracy over several years, often assisted by other members of the office staff. Our librarian, Mr H. G. R. King, Mrs Ailsa MacQueen of World Data Centre C for Glaciology, and the library staff of the Scott Polar Research Institute have been ever helpful in hunting for obscure references. Other students and staff have helped with compilation and the drawing of many diagrams; these include Miss Anne Swithinbank (now Mrs Anne Howe), Mr Rob Massom and Mrs Sue Jordan. The last named, and Mr Paul Cooper who provided valuable help in computing running means of isotopic data in chapter 6, have been able to contribute through their parallel work on an ‘Antarctic Glaciological and Geophysical Folio’, which is being produced with a grant from the Natural Environment Research Council under the editorship of Dr David Drewry, whose help and cooperation is acknowledged.

To some, and especially to the early contributors, it must have seemed that this monograph might never appear. I hope that the final production will serve to show both the tremendous value and the limitations of isotopic data as a record of past climate.

G. de Q. Robin

29 November 1981