

# *Preface to Fourth Edition*

Current concerns about global warming have produced widespread scientific interest in the behavior of glaciers in general and the polar ice sheets in particular. This increased interest, coming at a time of unprecedented advances in observational capabilities, has fueled a major expansion of the literature since the third edition went to press. A new edition to update the content and assess the current state of research was therefore overdue.

Reflecting the increased engagement of glacier studies with broad themes in environmental geophysics, the updated edition features new chapters on “Ice Sheets and the Earth System” and “Ice, Sea Level, and Contemporary Climate Change.” The chapter on ice core studies is significantly expanded from the previous version and much of it is new material. The content and arrangement of chapters on glaciological fundamentals broadly follow the outline of the third edition, although many discussions have been revised extensively. All the material about flow of mountain glaciers, ice sheets, ice streams, and ice shelves has been amalgamated into a single lengthy chapter entitled “Flow of Ice Masses.” Material about iceberg calving and basal melt now find their place in a chapter that reviews together all of the mass balance processes. In general the level of treatment remains unchanged, but several key topics are illuminated at a higher level of detail than in previous editions.

Many acknowledgments are due. We first must thank Shawn Marshall for conducting a first round of research and synthesis of topics presented in Chapters 4, 5, and 6. We gratefully acknowledge the scientists who reviewed individual chapters: Richard Alley, Bob Bindschadler, Jason Box, Roland Burgmann, Garry Clarke, Tim Creyts, Paul Duval, Andrew Fountain, Inez Fung, Hilmar Gudmundsson, Michael Hambrey, Will Harrison, Neal Iverson, Jo Jacka, Georg Kaser, Thomas Mölg, Tavi Murray, Tad Pfeffer, Eric Rignot, Jeff Severinghaus, Throstur Thorsteinsson, Françoise Vimeux, Ed Waddington, Joe Walder, Ian Willis, and Eric Wolff. Charlie Raymond deserves special thanks for commenting on the whole manuscript. Jeff Kavanaugh contributed helpful suggestions and graciously provided the cover photograph. Yosuke Adachi proofread the final manuscript. Mark Carey, glacier historian, suggested several of the chapter-head quotes. All of the reviewers offered excellent suggestions, some of which could not be accommodated for lack of space. We, of course, take full responsibility for the content and for the tough choices about what material to include.

Completion of the project would not have been possible without assistance from Delores Dillard and Darin Jensen of U.C. Berkeley’s Department of Geography. Delores worked on digitization and manuscript acquisition while Darin took on the nearly unthinkable task of drafting more than 200 figures. KC gives additional thanks to Jean Lave and Michael Johns for their wise counsel, and to the Division of Geological and Planetary Sciences at the California Institute of Technology, and especially Jess Adkins and John Eiler, who hosted a sabbatical visit at the start of this project. Finally, we express our deepest gratitude to Lyn Paterson and Pete Lombard for their many years of support and encouragement.

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*February, 2010*

## ***Preface to Third Edition***

The aim of this book and the level of treatment remain unchanged. The text has, however, been completely revised in order to keep pace with the extensive developments since the second edition was published. Changes in structure include a new chapter about the deformation of subglacial till, a previously neglected topic that is now of major interest, and reorganization of the chapters about flow in the different types of ice mass. Lack of space has forced the elimination of the chapter on measurement techniques and is also the reason for the continued absence of any discussion of glacial erosion and sedimentation. The chapters are now arranged in what is perhaps a more logical order; however, I have tried to make each reasonably self-contained.

I am most grateful to Richard Alley, Ian Allison, Roger Braithwaite, Nancy Brown, Garry Clarke, Kurt Cuffey, Dorthe Dahl-Jensen, Chris Doake, Paul Duval, Urs Fischer, Tony Gow, Bernard Hallet, William Harrison, Richard Hindmarsh, Almut Iken, Sigfus Johnsen, Roy Koerner, Anne Letréguilly, Atsumu Ohmura, Charles Raymond, Niels Reeh, Hans Röthlisberger, Joe Walder, and Chris Wilson for reviewing individual chapters. Their comments have resulted in many improvements; however, the responsibility for the final form and contents is mine alone. Word processing was in the capable hands of Shawn Marshall, Susan and Jeffrey Schmok, and Dan Stone.

T. S. Eliot remarked somewhere “The years between fifty and seventy are the hardest. You are continually asked to do things but are still not decrepit enough to refuse.” I shall be well beyond these limits by the time another edition is needed. This is probably fortunate. The vast expansion of the literature in recent years is making it increasingly difficult for one person to write a comprehensive account of the physics of glaciers.

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*June, 1994*

## *Preface to Second Edition*

Developments in the 12 years since the first edition went to press have made necessary a complete revision of the text. Extensive new field data have shown that, although the basic concepts developed in the 1950s still stand, many of them are over-simplified. As a result, theories have become more complicated and, in addition, computer modelling has added a new dimension to glacier studies. Nevertheless, the aim of the book remains unchanged. I hope that this is also true of the level of treatment, in spite of the increased complexity of the subject.

New chapters on ice core studies and glacier hydrology deal with topics that are now of major importance but on which little work had been done when the first edition was written. A new chapter on structures and fabrics in glaciers and ice sheets treats a subject to which I perhaps paid too little attention in the original book. The chapter entitled "Heat Budget and Climatology of Glaciers" amalgamates two closely-related topics that were previously discussed separately, while the new Chapter 3 is devoted to the mechanism of ice deformation and the flow law. Almost all the other chapters have been extensively rewritten.

The major part of this edition was written while I was enjoying the hospitality of the Department of Geophysics and Astronomy at the University of British Columbia (R. D. Russell, head). Numerous colleagues kindly devoted time to reviewing parts of the manuscript; comments by B. T. Alt, R. G. Barry, C. S. Benson, G. K. C. Clarke, W. Dansgaard, D. A. Fisher, A. J. Gow, M. J. Hambrey, W. D. Harrison, B. Holmgren, P. J. Hudleston, S. J. Jones, R. M. Koerner, J. F. Nye, C. F. Raymond, G. de Q. Robin, R. H. Thomas, and J. Weertman have resulted in significant improvements. However, the responsibility for the final version remains my own. R. C. Rumley did the final typing. Last, but by no means least, my wife Lyn typed all the drafts, helped with references, indexing, and proof-reading, and provided continuous encouragement in the often disheartening task of writing this book.

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Ottawa, Canada  
*May, 1980*

## *Preface to First Edition*

The aim of this book is to explain the physical principles underlying the behaviour of glaciers and ice sheets, as far as these are understood at the present time.

Glaciers have been studied scientifically for more than a century. During this period, interest in glaciers has, like the glaciers themselves, waxed and waned. Periods of activity and advance have alternated with periods of stagnation and even of retrogression when erroneous ideas have become part of conventional wisdom. The past 20 years, however, have seen a major advance in our knowledge. Theories have been developed which have explained many facts previously obscure; improved observational techniques have enabled these theories to be tested and have produced new results still to be explained.

This seems an appropriate time to review these recent developments. At present there is, to my knowledge, no book in English which does this. The present book is a modest attempt to fill the gap. To cover the whole field in a short book is impossible. I have tried to select those topics which I feel to be of most significance, but there is undoubtedly some bias towards my own particular interests.

While this book is intended primarily for those starting research in the subject, I hope that established workers in glacier studies, and in related fields, will find it useful. The treatment is at about the graduate student level. The standard varies, however, and most chapters should be intelligible to senior undergraduates.

I am much indebted to Dr. J. F. Nye for reading the whole manuscript and making many helpful suggestions. I am grateful to Drs. S. J. Jones, G. de Q. Robin and J. Weertman for reviewing individual chapters. I should also like to thank Drs. J. A. Jacobs and J. Tuzo Wilson for general comments and encouragement. The responsibility for the final form and contents of the book of course remains my own.

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