Review

HOOKE, R. LeB. 1998. *Principles of glacier mechanics*. Upper Saddle River, NJ, Prentice Hall, vii + 248 pp. ISBN 0-13243-312-5, Hardback. £28.95.

RECENT years have seen the publication of an increasing number of textbooks on glaciology as well as the appearance of a new set of texts on glacial geomorphology and glacial geology. *Principles of glacier mechanics* by Roger Hooke occupies a niche somewhere between the two, containing a selection of topics in glaciology, but with discussions using physical and mathematical concepts that are more sophisticated than those found in geology textbooks. Readers of Roger Hooke's papers will know that he writes well and concisely, and he maintains this style in a book of nearly 250 pages. It isn't a comprehensive textbook, but by occupying what is in effect Roger Hooke's area of glaciological research, it manages to be a stimulating and educative text. It contains a lot of information, and Hooke's clarity of expression also makes it a good book for dipping into. However, to call it *Principles of glacier mechanics* is a little misleading; something like "Topics in glacier mechanics and basal processes" would be more apposite.

I enjoyed this book because it is well written, stimulating and provocative. It is not for beginning students, but for more knowledgeable people who are in a position to know which parts they agree with and why. There is nothing quite like it in glaciology, especially its treatment of basal processes, but its overall coverage is selective and at somewhat varied levels. It does not treat glacier mechanics anywhere near comprehensively. If you are geologically or glaciologically minded, it is a strong candidate for the second glaciological textbook you should read, and as such it is excellent value; on the other hand, if you are a meteorologist or ice chemist who wants to know more glaciology, this book will probably not present the information you need in sufficient detail.

There are 12 chapters; chapter 1 is a statement of Roger Hooke's personal motivation, while chapter 2 contains some definitions of physical concepts. The technical level is that appropriate to an engineering undergraduate, but the pace is rather too brisk for it to serve as an introductory text on stress tensors and related concepts. True glaciology starts with mass balance in chapter 3. This chapter is rather selective in its choice of material. For example, it mentions the word "firn" once and gives little sense of the extent to which we can predict surface mass balance correctly, a key issue in modern glaciology.

The next chapter, on the flow of a crystalline material, is much more successful and is the best discussion of its kind available in English. There are some good didactic diagrams of the essentials of crystallography, and the idea of the deformation map is clearly explained. However, the reader is not going to learn how to interpret fabric diagrams from this text and there is little guidance on where to go to find out about the effect of anisotropy on ice rheology. Chapter 5 covers velocity distributions in ice. First, we learn the fundamental formula for shear stress. The applicability of this formula depends on the horizontal scales being considered, but this is not mentioned until a more specialised discussion on extrusion flow. The stress discussion is followed by a standard treatment of velocity distribution in ice sheets and glaciers, a seemingly rather specialised discussion of the effect of drifting snow on velocity fields, and a nice but brief discussion of ice streams.

The application of physical ideas goes somewhat awry in chapter 6. The fundamentals of heat transport are presented concisely, then applied to the centre of an ice sheet, and the ideas of the relative contributions of advection and conduction are described. However, there is a lengthy discussion on the use of approximate procedures developed a quarter of a century ago to estimate the effect of horizontal advection of heat on temperature distributions. These are approximate methods with unknown error magnitudes, essentially belonging to an earlier era of glaciological computing, when limitations on processing power imposed severe restrictions. They are educative when used in the right circumstances, but these are not really discussed in the text. Nevertheless, an extensive series of diagrams of basal temperatures from Antarctica, computed using these simple models, is presented with no mention of the computations done by Huybrechts in the 1980s, which incorporate all the relevant heat-transport processes and have set the glaciological standard for the 1990s. There are some tricky bits. For example equation (6.2) looks wrong but is in fact right because just at that point a heat flux is defined to flow positive in a negative direction. Equation (6.4) (the one-dimensional conduction equation) is wrong because it is expressed in terms of the spatial gradient of the thermal diffusivity rather than the conductivity; readers should use equation (6.3).

Chapters 7 and 8, on basal processes, are the best in the book and the best textbook discussions available. Chapter 7 considers the coupling between a glacier and its bed. There is a concise and effective discussion of the theory of hard-bed sliding and an up-to-date and critical discussion of till deformation and the coupling between ice and till; this discussion is necessarily not a consensus view. Chapter 8 treats glacial hydrology: classical areas such as vein flow and Röthlisberger channels and recent research on these topics, as well as newer concepts such as linked-cavity flow, transitions between drainage styles and the geometry of drainage networks. Recent work on drainage above deforming beds is also considered. There is a good discussion of Shreve's theory of how static pressure variations affect esker paths, and further stimulating discussions of the links between basal hydrology and glacial geomorphological development.

Chapter 9 discusses continuum mechanics: stress invariants, stress equilibrium and stress–strain relationships. This chapter differs little from anything one might expect to find in an engineering textbook, and its somewhat laboured nature could have been avoided by putting the discussion in the more general setting of tensor transformations. Chapter 10 considers the application of continuum-mechanical concepts to glacier flow. There is quite a long discussion of solutions for extending and compressing plastic flows, which date from the 1950s and have not been particularly useful in their application to glacier flow. In contrast, there is no mention at all of the extensive treatments, many of which are unique to glaciology, of how deviations from the infinite-plane assumption can be treated. Nor is there any mention of the (possibly wrong) back-pressure theories which have been so influential in dis-

cussions of marine ice-sheet stability. If there is such a discipline as glacier mechanics, these omissions constitute the fundamentals of the subject. There is a mistake at the foot of p. 176; in the infinite slab, incompressibility requires that $\partial u/\partial x$ is zero, which implies that the vertical velocity and not its derivative, as stated in the book, is constant. This impacts the subsequent discussion, the subject matter of which has in any case been treated more satisfactorily by Reeh and by Dahl-Jensen. Chapter 11 considers various topics in mechanics relevant to glaciology: tunnel, borehole and conduit closure. There is some glacier mechanics on how to estimate basal conditions from surface observations (but with no discussion of whether this is an inverse problem or not, or whether it is well posed). Students will not learn from chapters 9–11 why numerical techniques are appropriate in certain circumstances and why analytical techniques can and should be used in other circumstances. Chapter 12 deals with everyone's favourite part of glaciology, the response of glaciers to changes in mass balance. It includes some classical areas (kinematic waves and linear stability) and summarizes the fine discussion of time-scales provided by Jóhannesson, Raymond and Waddington.

The presentation of the mathematics in this book introduces some unnecessary difficulties. There are changes in notation and introduction of bold symbols for non-vector quantities. Varying levels of mathematical demands are placed on the reader — sometimes developments are worked through in great detail, whereas elsewhere they are more than brisk. Students will need an instructor for some parts. Nevertheless, they should find the book both stimulating and useful.

British Antarctic Survey RICHARD C. A. HINDMARSH
Natural Environment Research Council
High Cross, Madingley Road
Cambridge CB3 0ET
England

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