exploration. (Ian N. Higginson, Centre for History and Cultural Studies of Science, Rutherford College, University of Kent at Canterbury, Canterbury, Kent CT2 7NX.)

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ICE IN THE OCEAN. Peter Wadhams. 2000. Amsterdam: Gordon and Breach Science Publishers. xii + 351 p, illustrated, hard cover. ISBN 90-5699-296-1. £44.00; US$67.00.

There has long been a need for a comprehensive introductory text on the physics of sea ice, and this book goes a good way to meeting that. While there are a number of edited volumes that cover the field (most notably *The geophysics of sea ice*, edited by N. Untersteiner, and *The physics of ice-covered seas,* edited by M. Leppäranta), these lack the unification of a single-authored work, and are only as good as the weakest contribution. The present volume is based very largely on the author's own research: Wadhams is one of the foremost sea-ice scientists, and this book evidences both the breadth and depth of his work.

The book is structured into eight chapters. The first, largely descriptive, introduces the geography and oceanography of the polar oceans, with somewhat more emphasis on the Arctic than the Antarctic, although Antarctic water masses are said to be the more complex. A minor irritant in this introductory section is that the maps are reproduced from other publications and, particularly for the Arctic, have a variety of orientations (prime meridian up, 180° up, 90°E up, 150°E up) and some place-names discussed in the text only occur on maps that appear much later in the book. The following chapter on the processes of sea-ice formation, growth, and decay provides a comprehensive descriptive overview of the various types of ice and the processes by which they form.

The next two chapters deal with the thermodynamics and dynamics of sea ice, respectively, and introduce a more rigorous mathematical treatment. The chapter on dynamics is particularly well handled. Starting from the case of free drift of a single floe without ocean drag, the complexity and reality of the solution of the equations of motion are gradually increased, clearly explaining the physical concepts involved in each step and showing the basis of the various empirical models of ice drift. I would have liked to have seen the thermodynamics chapter handled similarly, starting with the simple case of heat conduction through a capacitive-less ice slab balanced by the latent heat of freezing (the Stefan relationship), using this to show the relevance of the various empirical freezing-degree-day relationships for ice growth, and gradually increasing the complexity of solution (including snow cover, variable thermal properties in the ice, radiation penetration, and oceanic heat flux) to the Maykut-Untersteiner model. The physical concepts are, however, not as well explained in the thermodynamics chapter, nor is it shown how the turbulent exchanges at the snow–air interface can be parameterised in terms of meteorological variables, although the turbulent exchange at the ice–water interface, where the relationship is seldom used, is given. Chapter 4 also covers the simple theory of wind-driven coastal polynyas (the Pease model), but without reference to subsequent developments of that model by, for example, Darby.

Chapter 5, which is by far the largest, deals with the statistics of the ice-thickness distribution and pressure ridges. It includes a section on techniques of ice-thickness measurement, which is a continuing key challenge for sea-ice researchers. However, this omits any consideration of the simple, but widely used, ship-based observation system that is being currently used by a number of national programs in the Antarctic to develop a climatology of relatively thin Antarctic sea ice. Differences between the Arctic and Antarctic thickness distribution are discussed, and some examples are given of applications of the thickness distribution. That part of the sea-ice cover close to the open ocean where processes of wave–ice interaction are important, the marginal ice zone, is covered in chapter 6. The structure and processes of the MIZ are first described, leading to a mathematical treatment of models of wave attenuation and of floe flexure and break-up. This chapter also includes an interesting analysis of possible mechanisms for development of ice-edge bands.

Chapter 7 deals with the other form of ice in the ocean, icebergs. This chapter is largely descriptive, although it is indicated how theory of drift and of flexure and breakup of sea ice developed earlier can be extended to much thicker icebergs. I found this chapter to be the weakest part of the book, with a number of small errors and statements subject to misinterpretation, particularly in the discussion of ice sheets, the source of the icebergs. For example the total snow accumulation on the Antarctic ice sheet is about double the 10^3 km^3 quoted by the author, and more recent estimates of the volume of ice in the Antarctic are about 10% less than the figure given. The assertion that 'if there were no melting from ice shelf bottoms, the icebergs being calved from the front of ice shelves would just be a few metres thicker' is contrary to the known loss of as much as 50% of the interior mass flowing into some ice shelves, and melt rates as high as 30 m a^{-1} beneath the deepest parts of the floating shelves. While the author undoubtedly realises that it is the increase in drainage of grounded ice from the inland ice sheet, which may follow ice-shelf collapse (although this is still subject to considerable glaciological debate), that will increase sea level, the unqualified statement that 'a greater rate of loss from the ice sheet by iceberg calving and ice shelf melting . . . could make a large contribution to sea level rise' is bound to be misinterpreted by some. This section finishes with a discussion of icebergs as a fresh-water source, a concept that in its original form relied on the fact that water in very large icebergs was 'packaged' for transport, although, as demonstrated in the first part of this chapter, icebergs are almost certain to breakup in the swell of the Southern Ocean.

The final chapter reviews the role of sea ice in high-latitude ecosystems, in the concentration and transport of pollutants, and in climate. The climate section focuses very much on climate change and associated changes to the sea ice itself, including recent significant changes in the Arctic Ocean.

The book is generally well edited and well presented. There are occasional irritating partial factual errors (katabatic winds are funnelled 'between mountain peaks'; PCBs are a 'type of pesticide'). There are also a few minor typographical errors and some errors in the bibliography (several cited references not in the bibliography, and inconsistencies between the text and bibliography). The bibliography also includes too many references to theses that are not generally accessible. A short section before the bibliography backgrounds other works (mostly monographs) that delve deeper. Note, however, that Jacobs and Weiss (1998) deals predominantly with continental-shelf oceanography and interactions between the ocean and meteoric ice (ice shelves, glacier tongues, and icebergs) — there is little on sea ice.

The book is well illustrated with mostly black-and-white photographs of sea-ice phenomena, although in some cases better examples might have been selected. Curiously, photographs by the author are credited to him, but no others receive any credit: this is somewhat different from the standard 'all photographs by the author unless otherwise credited.'

Does the book achieve its stated aim of providing an introduction to modern knowledge of sea ice and icebergs and the role that they play in the ocean system, largely from a phenomenological approach? In general it does, and it is certainly far more comprehensive and structured than anything else available is. Both the book's strength and some weaknesses derive from Wadhams' unique experience at the centre of many of the advances in sea-ice research over the last three decades. Nearly 10% of the cited references are to publications with Wadhams as principal author, and there are many more on which he is a co-author. With the author's wide personal knowledge, there is a focus on those geographical regions where his work has been undertaken, predominantly the Arctic and the Weddell Sea region in the Antarctic. But there is omission of some of the more recent work in other parts of the Antarctic that are quite different from the Weddell (work by investigators such as Worby, Jeffries, Lytle, Haas, and Ohshima). Certainly the book covers a wide variety of sea-ice processes, but these omissions do detract from it having a complete bi-polar perspective.

Readers with a sound background in applied mathematics will gain most from this book, but there also is much to be learned from it by those who do not. I would recommend the book as a valuable resource to researchers and postgraduate students of all disciplines involved in work in the polar oceans. (Ian Allison, Australian Antarctic Division and Antarctic CRC, PO Box 252-80, Hobart, Tasmania 7001, Australia.)

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PERMAFROST: A GUIDE TO FROZEN GROUND IN TRANSITION. Neil Davis. 2001. Fairbanks: University of Alaska Press. xvi + 351 p, illustrated, hard cover. ISBN 1-889963-19-4. US$35.95.

This book is written for the scientifically aware layman but contains much of interest to the specialist. The author is a geophysicist whose professional career was in atmospheric physics. However, Neil Davies has spent much of his life in Alaska, and is clearly enthused by the cryogenic phenomena that he encounters as part of his daily life. This enthusiasm is brought to his writing, and he cleverly carries the reader with him through complex explanations of ground freezing phenomena. Following an introductory chapter describing the nature and distribution of permafrost, the book may be divided into three general sections. Chapters 2 and 3 explain the fundamental physics underpinning cryogenic processes, chapter 4 is a review of cryogenic landforms, and chapters 5 and 6 consider applied aspects of permafrost geoscience, including the potential impacts of climate change.

The author begins his explanation of freezing phenomena in chapter 2 by focusing on the material properties and behaviour of water, particularly with respect to phase change. The discussion begins at the molecular scale and covers the fundamental physics of ice formation within soils and rocks. Chapter 3 discusses the processes observed during ground freezing, including water migration, ice segregation, and the formation of vein ice and massive ground ice. The style is easy and explanations are clear, making this a refreshingly accessible account of the physics of frozen ground.

Chapter 4 is concerned with permafrost landforms and sedimentary structures. Emphasis is given to lowland Arctic permafrost phenomena, with almost all examples drawn from Alaska and northwestern Canada. The nature and formation of ice-wedge polygons, pingos and related ground-ice features, mass-movement processes, patterned ground, and thermokarst are discussed, together with a very brief account of weathering in cold climates. Although chapters 2 and 3 generally provide a firm foundation for the process explanations in chapter 4, there are disappointing omissions. For instance, the thaw-consolidation theory is given only a passing mention on page 154, yet it provides