REVIEWS

LLIBOUTRY, L.A. 1987. *Very slow flows of solids. Basics of modeling in geodynamics and glaciology.* Dordrecht, etc., Martinus Nijhoff Publishers.

OVER past years the gap between two types of glaciological modeller has widened; there now seems to be little communication between the specialists in continuum mechanics, determined to purify and reform mathematical techniques, and the physicists, struggling to represent the real world of ice and snow as best they may. Professor Lliboutry has written this book for all modellers: to help the physicist to become aware of modern mathematical methods and to help the mathematician to understand the fascinating and complex behaviour of rock and ice on all scales.

The book begins with a broad introduction to modelling. This is an unusual mixture of standard explanations of basic terms — elasticity, viscosity, stress — and penetrating comments on methodology. The section on boundary conditions could be read with profit by modellers in any field. There follows a chapter on the Laplace temperature equation. Here we begin to appreciate the characteristic method of the author. The nature and methods of solution of the equation are explained plainly as in many mathematical physics textbooks. What is different is the attention given to the examples. These are not only of geophysical interest in themselves — for example, Fourier's calculation of geothermal heat flux — but also show the reader how to think about physical problems.

Chapter 3 introduces stress, strain, and the basics of tensor calculus, but the reader is not allowed to proceed directly to the solution of flow equations. Faithful to his purpose, Lliboutry insists first on a thorough grounding in the material properties of the substances to be modelled. Chapter 4 reviews the microscopic processes of creep and chapter 5 the macroscopic constitutive laws for the rheological behaviour of ice and rocks. Both chapters are packed with fascinating material; rocks or ice, the author's enthusiasm knows no bounds.

The reader is then introduced to two classic flow problems which have been treated using the assumption of uniform viscosity, isostatic rebound, and glacier sliding. The required mathematical techniques (Navier–Stokes equations, bi-harmonic functions, and Fourier transforms) are explained simply and clearly, but the most valuable part of the chapter is the review of the basal sliding problem, which has by no means been solved, even in the case of no cavitation.

There is more on basal sliding, cavitation, and subglacial hydraulics in the chapter on temperate valley glaciers. Unfortunately, the discussion of surges is very brief, but there are enough references to lead the keen student into the literature. Points of mathematical interest are the introduction of kinematic waves and an inverse problem — how can the velocities at depth in a glacier be deduced from measurements at the surface?

Chapters 8 and 9 introduce the most complex modelling problems, in which velocity and temperature are coupled. For glaciologists, these are, above all, the inverse and forward problems for polar ice sheets: prediction of conditions below the surface of the ice sheet from surface measurements and modelling its evolution under changing climatic conditions. Professor Lliboutry does not attempt an exhaustive review of the forward problem but provides a useful summary. His distinction between the short-term response of the lower boundary layer and the long-term response of the whole ice sheet is helpful.

Throughout the book, and especially in chapter 10, the author produces finite-difference schemes for the equations under discussion and shows how the stability of a given scheme can be determined. Chapter 13 introduces variational theorems and the finite-element method. It is rare to find this emphasis given to numerical methods but Lliboutry rightly wishes to deter the novice modeller from leaping in with home-made schemes. The sections on the propagation of errors in solution schemes for inverse problems are crucially important.

And so this astonishingly rich book continues; chapters on elasticity, perfect plastic behaviour, viscoelasticity, and transient creep; examples from plate tectonics (can we model the collision of India with Asia ?); tantalizing references to key glaciological problems (how should we include the properties of "Wisconsin" ice in polar ice-sheet models ?). There are even appendices with those odd bits of mathematics one always seems to need.

So are there no criticisms ? No doubt, there will be lively disputes about some of the new material in the book. However, my impression is that the author has been very careful to warn the reader whenever he is about to propound theories which are not yet generally accepted. My only real regret is that the book has not been read by an editor with English mother tongue. Despite Professor Lliboutry's formidable grasp of the language, there are places where the inevitable errors are a bar to understanding. But I would not wish to lose some examples of the authentic tone of the author: "Singularities shall not be conjured away by avoiding placing a node at the singular point"; "One may request more thought and less computer" ! There are a number of misprints, but these have already been indentified in an erratum sheet and will no doubt be corrected in the next edition.

It must be admitted that this is a dense, allusive book; not easy reading even for those with experience in the field. It is the summation of a lifetime's work by a profoundly original scientist and cannot be fully appreciated without long and careful study. But, despite the difficulties, it is an essential text for all glaciologists. Let us hope that the publisher can be persuaded to produce a reasonably priced paperback version soon.

E.M. MORRIS

SWITHINBANK, C. 1988. *Satellite image atlas of glaciers of the world: Antarctica.* Washington, DC, United States Government Printing Office. (*United States Geological Survey Professional Paper* 1386-B.)

THIS volume is the first published regional chapter of the USGS *Satellite image atlas of glaciers of the world*. The complete atlas, edited by Richard Williams and Jane Ferrigno, was formulated in 1979 to provide a Landsat image base line of global ice extent for the period 1972–82, and will include contributions from 50 scientists. This large project, originally to be published as one volume, has grown in scope, taken longer than planned, and is now being published as 11 separate chapters: one introductory chapter, nine regional chapters, and a topically oriented chapter. Antarctica (chapter B) is not only the first to be published but also possibly the most important in the series. This is not only because Antarctica contains the vast majority of glacier ice on Earth, but because at present less than 20% of the Antarctic ice sheet has been mapped at a scale of 1 : 250 000 or larger, and satellite imagery offers the potential of economically increasing this coverage and of monitoring any changes.

https://doi.org/10.3189/S0022143000005645 Published online by Cambridge University Press