# REVIEW

*The Physics of Glaciers;* by W. S. B. Paterson. P. viii, 250, figs. and photos. Oxford, New York, 1969 (Pergamon Press Ltd., $5.50 hardbound, $4.00 softbound).—Glaciology—the science of ice and snow—is a small but fast-growing interdisciplinary science. The challenge of the Antarctic ice sheet and the value of the continuous 100,000-yr precipitation and fallout record contained therein, the need for establishing a scientific understanding of snow accumulation and melt especially in regard to water resources, the environmental problems of ground ice and sea ice which are inhibiting the development of a major oil discovery in Alaska, the expanding interest in the Quaternary, and the need to establish firmly the climatic significance of major fluctuations in continental and smaller glaciers—these are some of the reasons for the present-day interest in glaciology. The field has developed in this country in spite of the handicap of lack of an English-language textbook (texts in Russian, Spanish, German, and French are available—the most modern, comprehensive, and expensive being Lliboutry's 1040-page Traité de Glaciologie).

Paterson's *The Physics of Glaciers* goes a long way toward remedying this deficiency. This book should have wide appeal: it is clearly written, critical in approach, modern, and inexpensive. A geophysical approach is used throughout; the author scrupulously avoids the morass of unnecessary classification, terminology, and description. Thus the book is in striking contrast to most chapters on glaciers in texts that deal with glacial geology, geomorphology, or physical geology. Although it covers only a part of the field of glaciology (or even of glacier-study), it does that much very well indeed.

Paterson begins with rather brief treatments of the transformation of snow to ice, the structure of ice I, and the fabric of glacier ice; this is followed by a discussion of mass balance definitions, techniques, and results. A treatment of heat exchange processes at the glacier surface is rather unsatisfactory and out of date. For instance, to assess the relative importance of various heat sources the author tabulates results from almost every experiment made on glaciers even though many of these results are now known to be invalid.

The quality of the book is immediately restored in chapters on glacier flow measurements, ice deformation, basal sliding, flow of ice sheets, temperature distribution, and the dynamic response of glaciers to changes in mass balance. Paterson frequently relates field measurements to modern theory, making the theory and its limitations more understandable. Most of the theory presented is that of J. F. Nye (freely acknowledged), and much of that remaining is attributed to J. Weertman; this book is a fine synthesis of Nye's and Weertman's prolific and important contributions. In view of the importance to Quaternary studies, however, it is surprising to find no mention of Weertman's work on the rate of growth and retreat of ice sheets. The chapter on temperature distribution correctly points up the importance of thermodynamic considerations. The author shares this reviewer's skepticism that such a thing as a

temperate glacier, pure and simple, can ever exist. Nondiffusive kinematic waves are dealt with at some length; the fact that this model is unrealistic is perhaps not emphasized strongly enough. In several places Paterson has supplied his own analyses to fill gaps in existing theory or to be more concise; however, some sections (such as the frequency response of glaciers to mass balance changes) are perhaps a little too terse and are not easy to follow. A short section on glacier surges is understandably cautious in view of the two 1969 symposia on this subject.

The book ends with a very short section on glaciers and climate which attempts to relate the meteorological problem of producing changes in mass balance with the rheological problem of dynamic response to the mass balance changes. The incautious reader may get the impression that the most important part of the relation of a glacier to its environment is solving the flow dynamics equations—this may be necessary, but it is far from sufficient. In spite of the photogenic subject matter, only three photographs appear, and two of these which need to be closely compared (Austin Post's famous before-and-after pictures of the Variegated Glacier surge) are on opposite sides of a tipped-in sheet (this sheet immediately separated and fell out of the reviewer's copy). Otherwise the format, typography, and line drawings are attractive and easy to read.

In short, the book is an excellent synthesis of modern knowledge of glacier flow, together with short descriptive sections of snow and ice, and glacier-climate interactions. Subjects that are not directly related to glacier flow analysis, such as Sorge's law, deep-core analysis, seismic and radar methods, and glacier hydrology, are not mentioned at all. This book is, therefore, recommended mainly to those interested in glacier flow. It will soon be on the bookshelf of nearly every glacier scientist; it should also be read by glacial geologists and will be of interest to those working on the plastic flow of rocks, snow, sea ice, and many other crystalline materials.

MARK F. MEIER